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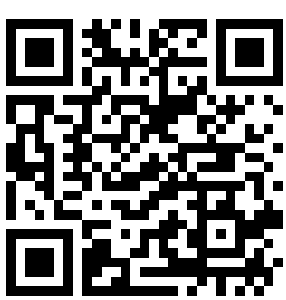
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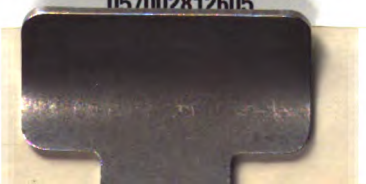






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THE

CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

GOVERNMENT ASSISTANCE TO RAILWAYS IN IRELAND.

A PAMPHLET on the above subject, being the substance of a paper read by Mr. G. W. Hemans, C.E., before the Institution of Civil Engineers, and an abridgment of the discussion thereon, has lately come under our notice.*

The publication of this paper and the observations on it may effect much good in calling attention to the feasibility of obtaining government aid in many cases requiring it, should the value and safety of the measure be once fully considered and established.

Although the question of government aid to railways under certain circumstances by either loan or grant might be advocated on much higher grounds than the mere calculation of what immediate and *direct* interest for the money might be calculated on and "guaranteed," we would, in these almost too much gold-governed times, be willing to give up that ground—merely using the statements in support of it as evidence of the benefit of extending and facilitating intercourse under any form, in undeveloped districts.

Mr. P. W. Barlow (p. 20) stated "the fact that, in Ireland, while the railway system had been assisted by government advances to the extent of upwards of two millions sterling, the national revenue had increased by that amount *annually*..... It was not too much to say, that government had received a rate of interest of 15 to 20 per cent. (per annum) upon the sum advanced."

Mr. Barlow had previously, and with perfect truth, remarked, that but for the government guaranteed aid to the Midland Great Western Railway of Ireland, that line would not have been extended to Galway, now "likely to become the high road to America."

It is clear therefore, from the short allusions and quotations made, as well as from the experience of the last half century, wherever loans and grants have been judiciously expended, as on the Highland roads and bridges and in many parts of Ireland, that the advantages resulting from such aid might be advocated on very high grounds indeed.

But to come to the more practical and business-like view of the subject, Mr. Hemans stated, it struck him that a public bill might be promoted, something on the footing of a bill for ordinary county works. Mr. Hemans proposes to give to the grand juries a compulsory power of assessment, on their presentment "that such a thing was necessary." Now, whatever power the grand juries in Ireland *did* possess, bordering on such absolutism—under the old 36th Geo. III. c. 55, still unrepealed—that power was effectually and so far wisely superseded by the 3 and 4 Will. IV. c. 78 and the 6 and 7 Will. IV. c. 116, called the Grand Jury Act, for it had been found in practice with grand juries, very much as Mr. Bidder (p. 22) stated it to be in the houses of parliament, that two or three individuals being ready and willing to do the work, and it being left to them, they naturally did it in their own way. To meet such an ordinary consequence, the new acts alluded to were passed, giving the grand juries only the power in strictly fiscal matters of sitting in open court and of presenting for such works as had been previously approved of by the ratepayers; therefore the absolute or compulsory bill could not have the approval of the government authorities in Ireland, being so contrary in its principle to the existing and reformed grand jury laws, and of course could not be expected to reach the House of Lords, or if there to meet with much, if any support at all.

Something equivalent to Mr. Hemans' suggestion might be carried into effect, by giving very little more power to the machinery of the baronial road-sessions and grand juries already existing and in use in Ireland, for the formation of ordinary public roads, and for the preservation of those works in repairs.

There are, no doubt, districts so peculiarly circumstanced, that although ultimately an ample return might be afforded for money expended in opening them up, at first starting a dividend could scarcely be expected, or that even the lowest rate of interest would be realised from the railway traffic until time would allow of the resources and capabilities of the country, with its new facilities, being in some measure developed.

In those places, to secure sufficient government loans for such opening up, the principle, with very slight variation, might be adopted which was (previous to 1846) applied to government grants for public works in Ireland. At that period, on an application for a grant in aid of a useful public work, the proprietor making the application was required to guarantee one-third of the cost of the work, as well as to lodge a sum for the investigation into its propriety and usefulness; on this, if the engineer's report or inquiry was favourable, the government approved of the grant being made, which never exceeded one-third of the whole cost of the work, and then the counties presented the remaining one-third, to be raised off the county or barony.

To work on this principle, the "subscribing contractors and directors of the line" (Mr. Hemans, p. 26) should be placed in the position of proprietors. It would not be too much to ask them to

* For report of Mr. Hemans' paper, see vol. xxi., p. 420.

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guarantee one-third of the deficiency of the working of the proposed rail, to make up a certain fixed moderate rate of interest.

This being satisfactorily arranged, and the project approved by the government officers, the loan might be sanctioned on the condition of the barony or the district sanctioning the guarantee of another third of a possible deficiency. The county at large at assizes to provide the guarantee for the remaining one-third, and to confirm the acts of the previous baronial sessions, as they now do.

The grants of one-third for public works in Ireland previous to 1846, which it is believed never exceeded £50,000 per annum (a sum less than the then woods and forest revenues of that country) caused a certain expenditure, as the act required not only twice as much more, but of three or four times its amount, for works following of necessity, to fully develop the advantages of the main lines or arteries of communication, thus *forced* as it were through districts otherwise impracticable from their position or their poverty: a quarter of a million was thus annually expended. It is not easy to reconcile the principle on which such an invaluable nucleus (as the small grant in aid had been) for the wise encouragement of expenditure, the employment of the people and the improvement of the country, was withdrawn, when the famine and prostration caused by the failure of the potato crop called for the most vigorous exertions and immediate outlay to mitigate so serious a calamity.

The good effected may be said to have worked its memorial in many parts of the country, and if the hints thrown out, arising from the very interesting paper read by Mr. Hemans, should lead to such, or to any practicable and equitable arrangement of the subject, we may yet hope to see railways in Ireland extended even to Black Sod and to Bear Haven. See what has been done in England at Saltash, to run out into the slender peninsula of Cornwall, to reach, it may be said, the single western port of Falmouth. Bear-Haven in case of war could not be over appreciated, and in the noble estuary of Black Sod bay, besides forming a superb refuge harbour for the western coast just where wanted, a fishery might be established, such as Ireland does not at present possess and England stands in need of as a navy training school, but which never can exist until the quick and certain mode of transit by railway shall be made available for the conveyance of the fish to market.

ST. MARY'S CHURCH, HUNTINGFIELD, SUFFOLK.

The alterations and restorations which have been for some time past going on in this church having been completed as far as relates to the nave and other parts of the body of the building, the same was re-opened on the 20th November last.

The works already perfected comprise the entire reseating of the nave, &c. with open seats of oak, of simple and proper character; three new windows in the north aisle, and one at the west end; a new pavement throughout of black and red Staffordshire tiles; with a general repair of the arches, columns, and other stonework, and a removal from the same of the accumulated whitewash of years. The further works contemplated and in progress are, the re-paving of the chancel with Minton's painted tile; a new reredos and east window; new stall seating of oak, and a new altar covering, the gift and work of Lady Huntingfield. The roof and ceiling also is being very handsomely and appropriately illuminated in gold and colour by the hands of Mrs. Holland, the talented wife of the rector, assisted by the advice of Mr. E. L. Blackburne, F.S.A., architect, of London, already known as the author of 'The Decorative Painting of the Middle Ages,' and other works on the same subject. This portion of the work promises to be a very attractive and successful application of colour to the internal decoration of the church, once so general, particularly in this part of the country, and of which several examples more or less contiguous still remain.

We would express a hope that the works already performed and now in hand are but a first instalment of those which, greatly needed, will sooner or later hereafter follow. The church is highly interesting in several points of view. It exhibits, as many of our parish churches do, though this is not generally the case in Suffolk, where the churches are for the most part wholly of Perpendicular date, portions of many different æra. The north arcade of the nave, and part of the north aisle and west end, is transitional Norman, dating about 1170; the south arcade and south aisle mainly Decorated. The chancel appears partly late Decorated with Perpendicular insertions, and partly Perpendicular.

The latest portion of the ancient church appears to be the porch, which dates about 1500. There is however, at the east end of the north aisle, a mortuary, or what was originally a chantry, chapel of the lords of Huntingfield, chiefly of more modern date, though doubtless wholly of ancient construction primarily, the present state of which will, no doubt, ere long meet the consideration and attention it so greatly needs. These sepulchral chapels are among the few ancient features yet connecting materially the lord of the soil with the parish church of his patrimony, and it is matter of great regret when, as sometimes happens, the associations involved in the consideration of this fact, and the many opportunities which the architectural preservation and connection of them with the churches to which they are attached, afford for the improvement of the latter, are lost sight of. In our old churches the sepulchral chapels of our forefathers were not merely dark and dreary tombs, to which access was only to be required when death had called another of the house to be its inmate. It was then an integral part, and constituent feature of the church, unshut out from view and companionship with all those feelings which the house of God awakens, and which makes it the desired last resting-place of all. There is no reason why this should not again be; or why the sepulchral chapel should not be kept up with due regard to and in accordance with the proper architectural character and condition of the churches of which they are adjuncts. It is questionable whether the act of Edward VI. for the suppression of chantries did more than abolish the religious observances, or masses, there anciently performed. The property in them was still generally taken to remain, and possibly yet does so, as may be evidenced in the allowed claim to bury therein.

Such being the case, let us hope that ere long the feeling of affection and reverence which all more or less entertain towards those whom we have loved and are now gone, and that desire which we all have to hold them in proper remembrance, may show itself generally, as it has done in one or two occasional instances of late, not only in the erection of memorial windows, but in the structural and permanent renovation of these long neglected dwellings of the "sleeping dead." The chapel at Huntingfield earnestly calls for some such attention as is here alluded to. It is now, architecturally and æsthetically speaking, in a very unsatisfactory condition.

The chief donors to the present restorations have been the Lord Huntingfield, patron of the living, and the members of his family, with the rector, assisted by a liberal grant from the parish funds.

ELASTIC APPARATUS FOR PAYING OUT TELEGRAPHIC CABLES.

A letter from Prof. Thomson, which appeared in our December number, contains an account of the behaviour of the apparatus employed in paying out the Atlantic cable, when subjected to the test of unfavourable weather. Prof. Thomson, speaking from his own personal observation, says this: "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." The meaning of this exhibition explains itself at once to any engineer. The cable was undergoing a series of violent jerks at intervals of a few seconds, at one moment being subjected to no strain at all, and the next to an impulsive tension the amount of which must have been very great. The cable was only saved from snapping by a rather rough-and-ready expedient. Relays of men were stationed at the brake wheels, to help them round when the cable became slack, so as to lessen the jerk when the next pitch of the ship pulled all taut again. In this way the danger was tided over for once, but it was only at the expense of paying out so large a quantity of slack as to render it doubtful whether the quantity of cable on board would reach the shore, even if no accident occurred. The average amount of slack expended during the first four days appears, by the log quoted by Prof. Thomson in his speech at the British Association (a report of which appeared in our October number) to have exceeded 30 per cent.; at times the waste was considerably greater than this, and it was only by throwing into the sea many hundreds of miles of cable in excess of the actual distance traversed that the cable was submerged without an immediate fracture.

In the course of his speech, Prof. Thomson alluded not only to

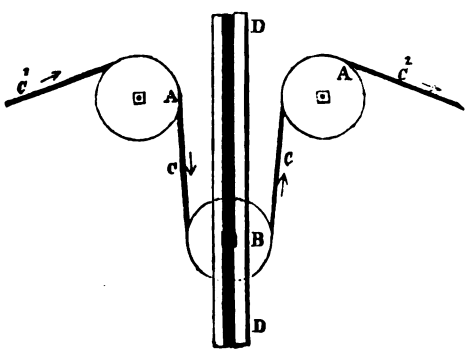
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the risk which had been run, but to the principle on which it might be obviated. After observing that the amount of slack which it was necessary to allow in order to avoid "the otherwise inevitable fracture of the cable" was very formidable, he expressed his opinion that that waste might 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."

The following is a description of a paying-out apparatus, invented by a Mr. Hemming,* for the purpose of supplying this desideratum. A, A (Fig. 1) are vertical sheaves whose axles work in a fixed frame. B is a similar sheave whose axle slides in vertical slots in a fixed frame DD. The axle of B is held down by a spring, which we shall presently describe more particularly The cable is made to pass through this apparatus after leaving the brakes, passing over the fixed sheaves and under the sliding sheave, as shown in the figure; C^1 C C C^2 being the cable coming from the brakes at C^1, and going overboard at C^2.

The working of the machine is easily seen. If from the pitching of the ship, the irregular speed of the engines, or any other cause, the motion of the ship is irregular, so as to tend to produce the jerking action experienced in laying the Atlantic cable, the above apparatus, if on a sufficiently large scale, and fitted with sufficiently sensitive springs, must provide an adequate compensation. We will suppose that the springs are in the first instance so adjusted as exactly to balance the upward strain of the double cable in the sliding sheave B. If the ship pitches and begins to increase the strain, the spring necessarily yields, and continues to yield until so much extra cable is allowed to go overboard as will suffice to ease the strain and bring the spring and the cable again into relative equilibrium. When a movement in the opposite direction occurs, and the cable begins to get comparatively slack, the spring draws down the sliding sheave, gathers up cable by increasing the length of the loop CBC, and so diminishes the quantity paid out for the moment as to keep the strain very nearly up to its average amount.

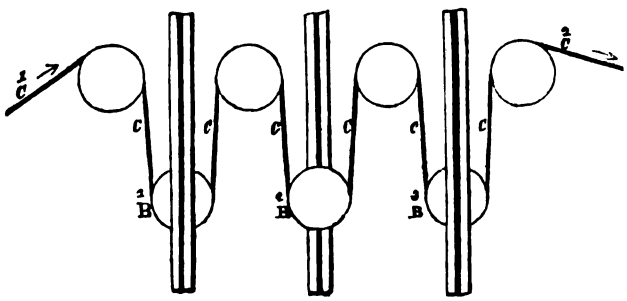
Fig. 1.



In order to make this apparatus work satisfactorily, it is essential that the quantity of cable which the apparatus can gather up and give off alternately should exceed the amplitude of the most violent oscillations of the ship. Different estimates have been formed of this quantity. For deep-sea work the play of the machine should it is thought be enough to give off 30 feet of cable on extreme occasions; and, in order to be prepared for the worst, Mr. Hemming proposes for Atlantic work to double this estimate. To get 60 feet of available cable would require a sliding sheave of 30 feet play, which could not be very easily stowed on board ship. But the same effect is obtained by using three sliding sheaves B^1 B^2 B^3 (Fig. 2), each having, say 10 feet of play, and each of course fitted with its own spring. For any voyage less formidable than an Atlantic one, two 10-feet sliding sheaves would probably be ample to compensate all irregularities in the ship's motion.

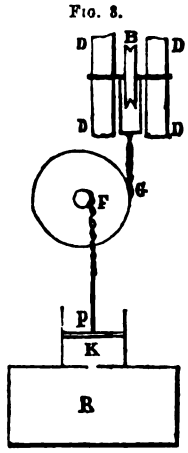
The next thing to be done was to find a spring which should be capable of considerable play under a heavy strain without any great variation in its force. No metal or india-rubber spring having a power of several tons would yield as much as eight or ten feet without a very large increase in its strain; and the only force at once strong enough, sensitive enough, and manageable enough for the purpose, is that of an elastic gas. Either steam pressure or atmospheric pressure must be employed, and in Mr. Hemming's apparatus the latter is preferred. The spring is in fact a cylinder fitted with an air-tight piston, the top of the cylinder being open to the atmosphere, and the bottom in connection with a vessel or reservoir exhausted to such an extent as will make the downward force of the piston sufficient to balance double the strain at which it is intended to work the cable. If the piston were connected directly with the sliding sheave it

Fig. 2.



would require a stroke equal to that of the sliding sheave, which if anything like 10 feet were the amount might be an inconvenient arrangement. This is obviated by making the piston pull a chain working on the barrel of a wheel and axle, while the sheave is drawn down by a chain working on the corresponding wheel. Fig. 3 shows the arrangement of the spring: B is the sliding sheave seen edgeways, and working in slots in the frame DDDD; F, G is the wheel and axle; P the piston, and R the partially exhausted reservoir in connection with the lower part of the cylinder K. The force of the spring will of course be the difference between the atmospheric pressure on the piston and the pressure of the rarefied air below the piston. If K and R be the contents of the cylinder and the reservoir respectively, π the pressure of the atmosphere, and ω the pressure of the air in R when the piston is at its lowest point, the variation in strength of the spring in a complete stroke (A being the area of the piston)

Fig. 3.



will be from $(\pi-\omega)$A to $\left[\pi-\omega\left(\frac{R}{R+K}\right)\right]$A. If we put $\omega=m\pi$ and $K=nR$, it is easily seen that the increment of force due to a complete stroke will be $\frac{m\,.\,n}{1-m}\times$initial force of spring. In other words, in giving off 20 feet of cable from each sheave, or 60 feet in all, the strain of the cable must vary $\frac{m\,.\,n}{1-m}$ per cent. This would probably greatly exceed any actual variation, because much less than 60 feet would be almost certain to give the requisite ease. But as a test of the sensitiveness of the spring, and a superior limit to the per-centage fluctuation of strain, we have the formula $\frac{m\,.\,n}{1-m}$. The larger R is, the smaller this will be; and what is also very material, the fluctuation diminishes when the average strain of the cable increases. The spring becomes more sensitive as its power is increased. Thus, if we suppose R to be of ten times the capacity of K, and the pressure of the air in R to be $\frac{1}{10}$ of the atmospheric pressure, we shall have $m=\frac{1}{10}$, $n=\frac{1}{10}$, and the fluctuation in the strain of the cable could not exceed $\frac{\frac{1}{10}\cdot\frac{1}{10}}{1-\frac{1}{10}}=\frac{1}{90}$, or very little more than 1 per cent. In working with less average strain, and consequently less exhaustion in the reservoir, the sensitiveness would diminish, but this would be immaterial, because it is only when working at high strains that such extreme delicacy would be wanted to insure safety.

It remains to describe the mode of obtaining always the requisite degree of exhaustion in the reservoirs, and consequent power in the springs. This might be done with sufficient rapidity for any change ordinarily required by simply fitting the reservoir with air-pumps worked by hand or steam, and with supply pipes for admitting air. But it sometimes happens that on account of

* The specification is No. 2246 of the year 1857.

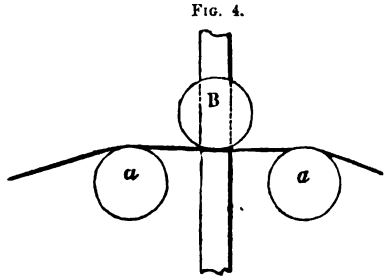
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the discovery of some defect or for some other reason it is necessary to stop the paying out of cable. The instant this is done the average strain begins to increase, and goes on increasing until it equals the weight in water of the length of cable corresponding to the depth. Besides this average strain there would, in the absence of an elastic apparatus, be the additional fluctuating strain which is due to the motion of the ship when riding at anchor by the cable, and which the elastic compensator is designed to obviate. In such a case as this, in order to keep the elastic apparatus at work, it would be necessary gradually to increase the force of the springs up to the average strain corresponding to the circumstances, and it might be impossible to work the air pumps with sufficient rapidity to do this. This contingency is provided for by fitting the air-pumps, not into the reservoirs K which communicate with the cylinders, but into larger independent vessels (not shown in the figure), where, if the expression may be used, a "store of vacuum" may be kept for the use of the springs. These "vacuum stores" are always kept exhausted by working the air-pumps from the engine shaft; or, when the engine is stopped, by hand or by a donkey engine. The lower part of each cylinder, or rather the corresponding reservoir R, is connected with a valve by which it can be opened, through a small pipe, either into the "vacuum store" or into the atmosphere at will. The handle of this valve is placed on deck near to the sliding sheave, and by moving it the engineer can increase or diminish the force of the spring at pleasure. A gauge is supplied for other purposes—chiefly to make the machine act as a dynamometer; but it is important to observe that in adjusting the spring it is not necessary to consult any gauge. If the spring is too weak the sliding sheave will remain permanently at or near its highest position, and if this is observed, the strength of the spring is increased by connecting it with the "vacuum store." On the other hand, if the spring is too strong, the sliding sheave will stick at the bottom of the slots, and air must be let in. When the strength corresponds with the average strain the wheel will be seen dancing gently up and down with every movement of the ship, and may thus be kept always at work by occasional inspection at intervals of half an hour or so, with closer attention at the time when the paying out is stopped.

If for any reason it is desired to put one or more sheaves out of gear, this is done at once by letting the air into the corresponding spring, when the sheave will rise to the position shown in Fig. 4, where it presses the cable slightly down merely by its own weight. By a slight tackle affixed to the axles, the wheel may then be instantly lifted a few inches, so as quite to clear the cable.

The difference between paying out a cable with this elastic apparatus and by the method now used, where the only relief that can be given is by easing the brake, is the same thing in principle as the difference between landing a salmon with an elastic rod and with a stiff pole. Without elasticity in the rod no angler could hold a fish, however rapidly he might wind and

Fig. 4.



unwind line from his reel. The contrast between a carriage on springs and one without them is another exact parallel. The greatest drawback to this apparatus, or indeed to any having the same object, is that it would take up valuable space on board ship, but this would be more than compensated by the reduced quantity of slack which would be required on board. Two or three hundred miles of the Atlantic cable, occupying much space, and worth £20,000 or £30,000, might very possibly have been saved by the use of an elastic compensator, and this would both have left room for the machine and have saved the company a very large sum, besides diminishing the risk of accident.

The importance of using elastic machinery is of course greatest in those undertakings where a very deep and open sea has to be traversed. But even in less formidable ventures fractures do happen, and more slack is spent at times than is at all desirable. Ten per cent. of slack or thereabouts may be useful on an uncertain bottom, and occasionally even more, but 30 and 40 per cent. is an extravagant waste, which nothing but absolute necessity can excuse. There is an impression among many experienced engineers that the fluctuations in the strain of a cable are of comparatively small importance, except on such voyages as that of the Agamemnon. The fact is, that the cable pays out when all is going well at an angle of not more than 15° to the horizon, and the visible motion of the ship being nearly at right angles to this is supposed not to cause any serious irregularity of strain. But a ship in a heavy sea has another irregular movement, which is less noticeable but infinitely more dangerous. No steamer toiling against a head sea advances with uniform velocity. As she plunges into a heavy sea her speed is perceptibly checked, and she gathers way again as soon as the wave has passed. This longitudinal oscillation probably tells more upon a cable than the mere pitching, and its amount has not been satisfactorily investigated. No dynamometer sensitive enough to register the sudden changes of strain caused by a heavy sea has we believe ever been used. The Atlantic one was perhaps as good as any, but its indications do not seem to have corresponded to the phenomena observed in the action of the cable, as the log does not mention the fact that the strain frequently dropped to zero. Indeed, on one occasion a perfectly sound piece of cable, which stood on trial a strain of 4 tons, broke with an indicated strain of not a third of that amount. The case of the Agamemnon was certainly an extreme one, when the fluctuations were sometimes from zero to 15 cwt. or more of indicated—and no one knows how much of actual—strain in a single pitch of the ship, but it is not unlikely that a close investigation would show more irregularity of strain and needless waste of slack even in laying cables in comparatively narrow seas than is commonly supposed; and in the case supposed of having to stop the paying out in a heavy sea, the existence of violent fluctuations cannot be doubted, for the pitching motion of the ship then becomes longitudinal to the cable, which hangs vertically downwards. The use of an elastic compensator would both measure and remedy the mischief, and would probably put an end to the mishaps which have already literally thrown many hundreds of thousands of pounds to the bottom of the sea. For any cable—especially having regard to the probable necessity of stopping the paying out on occasion—the machinery would be of great service, both in lessening risk and saving slack but for such experiments as laying an Atlantic or Gibraltar cable some such contrivance seems absolutely indispensable.

ST. PAUL'S CHURCH, HAGGERSTONE, LONDON.

The contract for this structure was let in March last, and such has been the rapidity with which the works have been prosecuted, that the edifice will be ready for consecration on the 27th inst.

The new church generally may be said to be designed in the geometric style of Gothic; its windows being all formed of pointed arches, the heads of which are more or less filled with tracery. Externally the walls are of brick, having stone dressings to the doorways and windows. Internally, more particularly in the roof, we observed several features similar to those followed in some continental churches, the adaptation of which has been very successfully carried out by the architect.

The plan of the structure combines a nave and side aisles, with a chancel and semi-octangular apse, the upper portions of the walls of both of which have been highly decorated with corbels and pendants supporting the hammer-beams of the roof. These have been carved in stone in the most admirable and effective manner by Mr. J. Tolmie, of Belvedere-road, Lambeth. The works consist of careful and artistic representations of the foliage of the vine, maple, bramble, columbine, passion flower, &c., and illustrate in a remarkable manner the great improvement which has been effected in the revival of decorative art in the Gothic style that has been effected in England within the last 20 years. Mr. Tolmie has in progress for this church a font of unique design, which will be fixed previously to the consecration of the edifice. The church is planned to seat about 1000 persons.

Mr. Arthur W. Blomfield, architect, St. Martin's-place, London, furnished the designs; Messrs. Holland and Hannen are the contractors; and Mr. Anstis the clerk of works.

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DELAMORE HOUSE, IVYBRIDGE, DEVON.

(With Engravings.)

THIS mansion is now in course of erection near Ivybridge, South Devon, on a site commanding a fine view of the Slade valley and viaduct, and is intended for the family residence of the owner.

Our illustrations show the entrance or north front, and the ground and first floor plans. There is an attic story to the main building, and convenient offices surround the court-yard at the east end of the house.

The walls will be faced with dressed granite of a pink colour from Dartmoor, in the immediate neighbourhood, and the dressings to doors, windows, &c. will be of white granite from the same locality. The cost of the building will be about £10,000.

The whole is from the designs of Mr. J. P. St. Aubyn, architect, of John-street, Bedford-row, London, and Devonport. The contract has been taken by Mr. Roberts, builder, of Plymouth. Mr. James Gabbraith is the clerk of works.

References to Plans.

Ground Plan.

A.—Porch.
B.—Lobby.
C.—Hall.
D.—Corridor.
E.—Library.
F.—Dining-room.
G.—Drawing-room.
H.—Ladies'-room.
I.—Gentlemens'-room.
J.—Butler's pantry.
K.—Butler's bed-room.
L.—Stairs.
M.—Lobby.
N.—Kitchen.
O.—Housekeeper's-room.
P.—Store and china closet.
Q.—Scullery.
R.—Pantry.
S.—Dairy.
T.—Larder.
U.—Servants' hall.
V.—Back stairs.
W.—Brushing-room.
X.—Fuel shed.

First-floor Plan.

a.—Stairs.
b.—Landing.
c.—Corridor.
d d d.—Dressing-rooms.
e e e e.—Bed-rooms.
f.—Bath.
g.—Sitting-room.
h h.—Water-closets.
i i.—Landing.
k k.—Passage.

ON THE REMAINS OF PAINTED DECORATION IN SOUTHWOLD CHURCH, SUFFOLK.

(Continued from page 383, vol. xxii.)

THESE cherubim and angels, the latter of which are also continued in the hammer-beams of the nave, appear to have been especial objects of dislike to the parliamentary visitor, William Dowsing. In his Journal, under the date April 8, 1643, we have the following entry in relation to the defacements committed and directed by him in this church. "Southwold, April 8: We brake down one hundred and thirty superstitious pictures, St. Andrew, and four crosses in the corners of the vestry, and gave orders to take down thirteen cherubim, and to take down twenty angels, and to take down the cover of the font." It may be considered fortunate that these thirteen cherubim and twenty angels were constituent parts of the roof and not merely ornamental attachments, so that they could not without letting down the whole be taken away. In this difficulty a sort of compromise seems to have taken place, and the angels and cherubim were subjected to *capital* punishment, and so remain, headless, to the present day. The pictures, with figure of St. Andrew, and the crosses in the vestry were less hard to be summarily dealt with, as was also the font cover,* which no doubt disappeared shortly after his order.

But to return. The western bay of the chancel roof, as before observed, differs in its decoration from the rest just described. Here, instead of the "painted heaven," indicated by the blue ground and starry powdering of the more eastern portion, enrichment of a more elaborate character is introduced. Each panel of this bay has the figure of an angel, in reference to the angelic choir, bearing in alternate order, a scroll inscribed with the "Benedictus," or song of Zacharius, and one of the implements of our Saviour's passion; the text commencing in the upper north-eastern panel of the bay with the words "Benedictus dominus," and terminating in the south-western lower panel with the words "pueri sui." The angels are winged, the under and upper, or pinion, feathers being alternately red and green, are all clothed in white garments, have crowns of gold upon their heads, and are represented as issuing from the clouds, which however, contrary to the more usual conventional mode of representing such in the middle age, take the form known in heraldic language as wavy instead of nebulæ. The ground of the panels on which the angels are painted is a deep blue, and there is a golden star in the four corners of each panel. In the two smaller panels on each side, which adjoin immediately upon the wall cornice, is inscribed, on the one hand, or north, "Te deum laudamus;" and on the other, or south, "Te dominum confitemur." The main timbers and the intermediate ribs of the panels are all painted to accord with those of the rest of the chancel roof, and there are similar gilt bosses and flowers, &c. at the intersections. Some of the implements of the Passion introduced are curious. There is in the hand of one angel the lanthorn, in another the iron bar with which the bones of the two thieves were broken, in another the sword with the ear of Malchus adhering to it, and by the side of this figure on a stool a representation of the cock, on hearing which for the third time "Peter went out and wept bitterly." (Luke xxii., v. 5.)

The character of the greater and different enrichment here exhibited, and the connected relation it had to the rood, or what was the ancient finish of the chancel screen beneath, is very interesting and suggestive: another example equally so, or where the reference is so directly pertinent and tangible it might be difficult to find. At Mendlesham, Cratfield, and a few other churches, the same principle of more highly enriching the roof over the place of the rood likewise occurs, but the paintings in either case are not so elaborate or of so immediately referential a nature to the Passion of our Lord represented in the rood below, as at Southwold. At the former the panels have the monogram I.H.S. Those at Cratfield have alternately the Holy Name within the crown of thorns, and a crowned M.R.*

In connection and juxtaposition with the painted enrichments here described are those of the chancel screen beneath, with the two smaller screens, which extending north and south of it, form the western inclosures of the chapels of the Holy Trinity and the Blessed Virgin, occupying originally, as before mentioned, the east end of the north and south aisles respectively. These screens are altogether among if not the very richest examples of painted decoration as applied to such features remaining in Suffolk, if not in England. Very many similarly ornamented screens exist both in this and the adjoining county of Norfolk, while some are found also in Devonshire and other of the western counties, all more or less possessing particular interest or peculiar merit, as at Attleborough near Norwich, where the panel figures are of very large size, and occupy the upper instead of as more usual the lower panels, and at Eye, Tunstead, and Filby, where the same exhibit more than the common artistic excellence in the drawing and finish;† but for the elaborate nature and extent of the ornamentation few equal the chancel screen at Southwold. This screen is divided in its length across the body of the church—to which extent as a chancel screen it is properly limited, though it is customary to consider the rood screen as including those of the aisles, or side chapels, from the loft being usually continued over them—into, as usual in the larger examples, six main compartments, three on each side of the doorway; the lower or panelled portion of each being again subdivided into two smaller compartments, forming in the whole twelve panels filled in with traceried heads of very elaborate character, and separated by tabled buttresses at the main divisions, and by square detached shafts set angle-wise, and capped with an elongated ogee as finial, at the intermediate muntins; the six upper compartments being pierced or unfilled in, and terminating each in an arched head foliated with a peculiar pendant or hanging tracery, repeated on both faces, of great delicacy and lightness, common to many of the Norfolk

* Some of the font covers of Suffolk and Norfolk are very fine, and show remains of very elaborate painting. That at Ufford, near Woodbridge, is one of the richest. It is of very great height, reaching nearly to the roof of the church, and has been covered with painting and gilding, a good deal of which remains. There is another at Castle Acre, Norfolk. Another remains, though unused and hung up at the west end, at North Walsham. St. Gregory, Sudbury, has a fine font cover; the painting of which however has been subjected to restoration. Worlingworth had one. Those at Ufford and Sudbury are represented in Vetusta Monumenta, vol. iii. p. 25. Salle has also one, and there were unt l comparatively lately, if they do not now remain, similar covers at Elsing in Norfolk and Sporle in Suffolk.

* At St. Mary's, Bury, the principals of the bay over the rood loft are painted in richer character than those of the rest of the roof, and bear scripture texts inscribed. At Ilfracombe, Devon, the part of the roof over the place of the rood loft is painted, the remainder of it being without colour; and a late example of the practice occurs at Islip, Oxon. (See Oxford Glossary. Art. Ceiling.)

† A very numerous list of screens retaining the original painting in greater or less extent and preservation, might be given, but would too far extend a notice like the present.

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and Suffolk screens. The original finish above the arched heads no longer remains, having been destroyed doubtless under or about the time of the injunction of Edward VI. for the demolition of roods. This termination, as is evident from the remaining traces, consisted of the usual groined canopy and loft or stage above, similar to that which still remains almost perfect, since it wants only its parapet and cresting in the neighbouring church of Bramfield, near Halesworth, and in a like state, or nearly so, in a few other churches.*

While on the subject of this or a similar finish to chancel and other screens it may be observed that, there seems no reason why such should not be again restored, at all events to the extent of the groined vaulting with a cornice and cresting above: such is in fact the finish expressly stated in an injunction of the 3rd of Elizabeth as that intended or enjoined for them. The order of Edward for the taking down of roods applied in the first instance, simply to the removal of the rood figures, *per se*, being afterwards erroneously concluded to extend to the rood loft or gallery of access to them. This gallery was formed on the upper beam of the screen, into which the joists of it, with the supporting timbers of the rood figures, were framed, and its either side was defended or fenced in by a parapet along its length, to secure safe passage across. It was this gallery or passage to, and as such connected and associated with, the objected-to rood figures, that it was the object of the reformers of Elizabeth's time to do away with, as is very clearly and explicitly shown by her order. The indiscriminating ignorance and prejudice of the age, however, failed to distinguish between transposition, "transposed" being the word of the order, and destruction, as it had already done between reformation and abolition, and from the lack of a clear understanding, or a wilful misconception of former orders, had with the rood gallery and its figures pulled down, and were continuing to pull down, the entire upper portion of the screen, extending the demolition in some instances to the entire structure of it;† leaving them as that at Southwold, and in a number of other cases, is now seen, stripped to their naked framing and entirely denuded of their upper part. To this condition it was not the authorised intention to reduce them. Elizabeth's order just referred to, clearly defines the extent to which they were to be altered, and the mode in which they were to be finished and left after such alteration; the words are as follows:—"It is thus decreed and ordained that the rood lofts"—roods had already been previously for the most part removed—"as yet, being at this day aforesaid, *untransposed*, shall be so *altered* that the *upper part* of the same with the *soller*"—an old term for an upper story—"be quite taken down unto the *upper parts of the vautes*" (vaulting) "*and beam* running in length *over* the said vautes, by putting some convenient crest upon the said beam towards the church;" that is to say, the rood loft or gallery was to be taken down to the beam or cornice above the groined canopy or vault, and was there to be finished with a crest ornament or brattishing, the common mode of finishing such a cornice or termination. This is the exact state in which the loft of Bramfield appears to have been left, if the cresting is excepted, the place of which appears to have been supplied in 1604 by tablets of the commandments, in accordance with the canon then promulgated.‡ It also exactly describes the manner in which many of the screens inclosing chantry chapels, where there was no rood loft, were originally finished, and a state in which they remain in several instances to the present day. At East Harling, Norfolk, the screen at the east end of the south aisle finishes with a groined canopy and cornice and a cresting above, showing evidently the appearance and kind of finish intended in Elizabeth's order.

The painted enrichments of the canopy at Southwold can only now be judged of by reference to those of similar erections still extant, and the one or two fragments mentioned in the note below as now remaining fixed on the upper part of the screen. The customary decoration of the panels of the groining was a blue ground studded with small gilt stars. At Bramfield they are so ornamented, as well as at East Harling and a number of other instances which might be named. In the former, the stars are stamped in relief in mastic, and interspersed with small four-leaved flowers in the same composition, small figures of cherubim occupying positions in the upper part of each panel. The beads and hollows forming the ribs of the groining are, the former gilt, the latter blue in one compartment, red in the other, and so on alternately; the fillets between being gilt. A somewhat similar treatment would appear from the remains to have been exhibited at Southwold. The springing shafts of the groining are left and are spirally banded, gold in alternation with a diapered pattern of dark brown colour, with which it is probable the beads of the vaulting accorded, or being smaller, were simply gilt, as the lesser beads of the screen are both here and at Bramfield. The fragment of the loft parapet exhibits a series of small traceried arches, the fillets of which are gilt, the ogees alternately red and blue, and the hollows white ornamented with flowers, similar to those which appear on the hollows of the screen itself, and the portion of the upper moulding shows red and blue, relieved by gold fillets, with a carved and gilt enrichment filling the larger hollow, the ground of which is a deep bright blue.

The enrichments of the rest, or remaining portions, of the screen we are however not left to conjecture for. They exist in unusually perfect condition. The main divisions or muntins of the screen consist of filletted ogees and hollows, separated by beads, which, continuing round the arches, are there formed into the pendent tracery already mentioned. On the face of the muntins towards the church are cusped and pinnacled buttresses of three stages, terminating in a circular shaft with moulded cap and crest, which originally received the springing of the groins: on the chancel side the face has a bold bead terminating with a crested cap in the same manner. The doorway is formed and comprised in the two central compartments, round the arch of which the same kind of pendent tracery to that of the arch heads is continued on both sides; the upper or crowning moulding of the arch having very richly carved crockets, also repeated on both sides. The inferior divisions, or those which separate the panels in the lower part, are formed also by an ogee and hollow, with bead between, and have on their faces towards the church, a detached shaft or pinnacle, as before mentioned, which terminates in a cap and elongated ogee as finial at the base of the springing of the tracery of the panels.

Such is the general formation and aspect of the chancel screen. Its painted enrichments may now be described as follows:—The buttresses and intermediate detached shafts, with their pinnacles and crockets, are all gilt; the front faces of the latter being diapered in colour and gold, those of the former in various patterns in relief in mastic; among which small niches are introduced, holding diminutive figures on coloured grounds of glass, or some such substance. The ogee or outer moulding of the muntins is in one compartment divided by a waving line of green and white, and in the other compartment by a waving line of red and white, charged each with a small flower, red on the white ground, gold on the red and green. The bead next the ogee is gilt, and in the panel parts enriched with small stamped flowers in relief at intervals, as are the fillets of the panel tracery, and its flowered cuspations; above the panels, or in the open upper parts of the screen, it is simply gilt, and the pendent tracery is the same. All the crocketting and the fillets of the label or arch moulding of the doorway, are likewise gilt. The hollows next the bead on each face of the screen are grounded white, enriched with flowers at intervals, alternately red with green leaves, and green with red leaves. The fillet or soffit between the two hollows is red where the outer ogee is green and white, and green where red and white. The large bead or shaft on the chancel face of the muntin is banded spirally black, or very dark blue, and white. The small fillets between the beads and hollows, with the edge of the ogee on the church side, which is slightly splayed, is a crimson red. The middle rail, which tables in two splays, has the upper one alter-

* At Hanborough, Oxon. the loft still exists across the aisles (see Guide to Architectural Antiquities of Oxfordshire); and at Charlton in Otmoor, in the same county, it yet remains perfect (Hierurgia, p. 186.) The Cambridge Camden Society's "Words to Church builders," mention the following churches as also retaining the rood loft:—Llanegryn, Merionethshire; Balsham and Guilden-Morden, Cambridgeshire; Montgomery, Montgomeryshire; Clynog, Caernarvonshire; Conway in same county, and Llanwrst in Denbighshire The Oxford Glossary (Art. Rood-beam) notices several others more or less perfect. At Attleborough, Norfolk, the rood screen with its loft is all but quite so, though now removed and fixed at the west end of the church.

† The churchwardens of St. Mary, Bungay, were about this time removed from their office for having sanctioned the removal of the chancel screen, while with respect to such feature it was expressly enjoined that there should still be one in every church; and accordingly a new screen or "partycion" was directed to be made at the cost of the parish. (See account book of St. Mary, Bungay, quoted in proceedings of Society of Antiquaries, vol. iv. p. 155.)

‡ Here the taking down appears to have been confined to the strict letter of the order, that is to say with reference to the church side only. On the chancel side of the screen the parapet of the loft, which is however unusually low, yet remains as originally formed. At Attleborough the loft and its parapet was retained altogether, and on the face of the latter scriptural texts were painted, traces of which show themselves beneath the coats of arms of the several English bishoprics which have been subsequently added. The words from Proverbs, c. iii., viz., "Put thy trust in God with all thine heart," &c., are inserted in the hollow of the cornice above the groined vaulting. At Southwold the compliance with the order for painting "some convenient crest upon the beam towards the church," is singularly enough exhibited. A portion of the old upper moulding and part of the parapet apparently, is nailed upon the naked framing of the screen which is exposed by the removal of the groining above the arch heads.

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nately red and green, and the lower green and red, in accordance with the general counter-changed arrangement of the rest of the colouring, each relieved with a kind of scroll ornament of foliage and pomegranates, the latter stamped in mastic and gilt. Beneath this, the traceried heads of the panelling have, as before noticed, gold fillets, with richly carved crockets and cusp-flowers, all gilt, relieved by white hollows, studded with small flowers green and red; the ground within the tracery and to the level of the springing of the same being alternately red and green, powdered with stars and flowers in colour and gold. At the foot of each panel traceried circles with a flat pedimented battlement, which are here inserted as a finish above the cill of the screen, exhibit a similar arrangement of colour and ornamentation, and the whole is completed by the painted figures of the twelve Apostles, each with its distinguishing emblem,* and clothed in robes covered with the richest diapers in colour and gold; the back grounds representing hangings, being stamped in relief in mastic, in various patterns, and also gilt. These figures are, for the most part, in fair preservation, as is generally the rest of the decoration. The diapered dresses are, with one or two exceptions, nearly perfect, but the faces have been rubbed away and mutilated to some extent. The colours of the gilding, however, are surprisingly vivid, considering that time and neglect have laid no light hand upon them.

It is observable, with reference to the chancel screen and the painted representation of the Apostles thereon, that there is generally a prevalence of the same arrangement as respects the position of the figures in all the Norfolk and Suffolk screens, and particularly of those of St. Peter and St. Paul. These two are usually placed, the former on the north or Gospel side, and the latter on the south or Epistle side, of the doorway. They so occur at Randworth, Tunstead, Trunch, and Kenninghall, as well as at Southwold; the remainder following in less arbitrary, though frequently in the same order, and being sometimes accompanied with other saintly figures. At Tunstead, in addition to the Apostles, the four doctors of the church, St. Augustine, St. Ambrose, St. Gregory, and St. Jerome, are introduced in the extreme compartments at either end; and at Worsted other introductions occur. At Southwold the Apostles only appear, and in the following order:—on the north side, proceeding northward, St. Peter, St. Andrew, St. Thomas, St. James the less, St. Matthew or St. Matthias, and St. Philip; on the south side, proceeding southward, St. Paul, St. John, St. James the greater, St. Bartholomew, St. Jude, and St. Simon.

There is a peculiar significance in the introduction of the apostolic figure on the chancel screen, which was carried still further under the existence of the rood figures which were anciently placed above, and which, as connected with the symbolism, or referential nature of such admissions, is very interesting and suggestive. The symbolism of the rood with the painted portraitures below was to the effect that, by the Passion of Christ there represented, and the teaching of the Apostles, in figure also depicted, an entrance to the heavenly kingdom, of which the chancel was viewed as the material type on earth, is opened to the faithful believer; a signification which may be fitly, perhaps, continued—as it was apparently in some cases—where the introduction of the rood is, from religious objection, inadmissible. With further similar symbolic indications, in some old screens where the Apostles are painted on the panels, the open entrance so left is taken to be typical of Christ, as "the means and the way." In others, where a door fills the central opening, the figure of the Saviour is, with more direct expression, painted on the door. This is exemplified at Houghton-le-Dale and Castle Acre, in Norfolk; and, taking the simple view so expressed, there seems hardly a more appropriate decoration, or one less open to just cavil.

The particular reference to purport and position, symbolic or otherwise, here exhibited, characterises generally the pictured decoration of the middle age, and of this the side or aisle screens at Southwold, which may next be noticed, are an evidence in addition to that of the chancel just described.

The upper part of both these screens was finished originally with a similar groined canopy to that of the chancel screen. As with the latter, however, such no longer exists, the naked framing of the construction being now in like manner exposed. The general form and arrangement of both is the same as that of the chancel screen, and the sections of the mouldings also, though somewhat smaller. They are each of six main compartments, exclusive of a central doorway, three being on each side; their length is each about 18 ft. 9 in., and their total height to the upper beam about 12 ft. 9 in., that to the top of the middle rail being 4 ft. 9 in. The upper compartments are open, and have arched heads and pendent tracery on both sides, of the same description as the chancel screen, and the lower compartments of each are subdivided in the same manner into twelve panels, containing painted figures. These latter, referring to the particular dedication of each chapel, are on the south side, or to the chapel of the Blessed Virgin, the greater or lesser prophets; the name of each being inscribed on a scroll beneath the figure, as follows:—South of the doorway and southward, DAUID: PHA. ("propheta"), AMOS: PHA., with Isaiah, Jonah, and Ezekiel—the sixth or last panel entirely defaced. North of the doorway and northward, MOYSES: PHA., HELIAS: PHA., with Jeremiah, Naum, Osea, and Baruth; and on the north side, or to the chapel of the Holy Trinity, the heavenly hierarchy, or several orders of angels,* each with its proper name on a scroll beneath; the outer panels, right and left, having other angels bearing shields charged respectively with the emblems of the Blessed Sacrament† and the Holy Trinity.‡

The colouring of the principal mullions shows a similar treatment to that of the chancel, though with a less introduction of the stamped or relieved mastic ornament; the latter being limited to those parts of the faces of the buttresses immediately under the pinnacles at the tablings, and to the flowers on the middle rail, and the main ogees. There is also the same alternation or reversed order of the colour; the ogees being, in one compartment green, and in the other red—not waved, however, as in the chancel screen—the fillets to the panels in the lower being red where the ogee is green, and green where the ogee is red. The beads and pendent tracery are gilt, as are the fillets of the tracery heads of the panels; the hollows in every case being white, studded with small flowers—the eyes of the same red and green, to alternate with the red and green ogee. The grounds of the tracery heads and of the panels are dark blue, studded with gold flowers. The lower parts of the panels, as with the chancel screen, have small traceried panels, with a centre shield; those to the north screen, Or, charged with a merchant's mark, or monogram; those on the south screen, Argent, charged with the cross of St. George, Gules; the fillets and grounds of the panels being alternately green and red, the hollows, as the others, white. The lower portions—that is to say the panelled parts—of both these screens are less richly ornamented in front than on their east or chapel sides. Here there are no figures, and the grounds have been ornamented with a diaper pattern, which, however, is now much defaced, particularly in the case of the screen on the south side, the figures on the front of which have also been very much injured; Moses and David being the most readily identified, though the traces of all can, with a little pains, be discerned. Those on the north screen are very perfect, and the colour and gilding is in very fair preservation.

This latter screen appears, from the remains of an "Orate pro animabus" on the scrolls beneath the angels in the outer panels, to have been the gift of one John Gueman and Catherine his wife, anciently a wealthy inhabitant of Southwold, whose place of burial in the church Gardner describes as east of the pulpit, by the north aisle, where, he says, a brass, with the inscription, "ORATE PRO ANIMABUS JOHANNIS GUEMAN ET CATHERINÆ UXORIS EJUS," formerly existed.§ This position, or near to the rood

* The Evangelists have in addition the evangelistic symbol, attached as part of the ornamentation of the buttress faces which adjoin upon their figures. These symbols are stamped in very bold relief within circles in mastic and gilt.

* Arranged as follows:—South of the doorway and southward,—Serafyn, Thrones, Principatus, Virtutes, Angelus (probably Raphael), Angelus with emblem of the sacrament. North of the doorway and northward,—Cherubyn, Dominationes, Potestates, Archangelus (Michael), Gabriel, and Angelus with emblem of the holy Trinity.

The figures of the heavenly heirarchy occur in other instances. They are represented on the chancel screen at Barton Turf, Norfolk (see original papers of the Norwich and Norfolk Archæological Society), and some of them were among the figures on the chancel screen at Tavistock, Devon (see Gent. Mag.)

† Gules, three chalices *Or*, with the sacramental wafer inscribed with the holy monogram, *Argent*.

‡ On a field *Or*, within a bordure triangularly continued and connected by circles at the angles and centre, the words "Pater non est filius, non est spiritus sanctus, nen est pator, est deus."

§ These memorial "orates" were commonly affixed to such and other gifts to the church in the middle ages, and it is worthy of thought how far the mementoes of the present day might not take the like form of permanent and constituent parts of the church, rather than mere extraneous and attached slabs and mural tablets. The old architects in the generality of instances made such structural or useful features of the building. At Worsted, Norfolk, the chancel screen is a memorial to the donor, as may be seen by the "orate" inscribed on the scrol which ornaments the middle rail. A like example occurs at Burlingham St. Andrew, near Norwich, where the names of the donors are introduced under the saints represented on the panels. At Attleborough, there is in like manner an "orate" on several of the panels, as a memorial either to the contributors jointly to the screen, or to those who may have provided the cost of each panel. At Blythborough, Suffolk, the font has an "orate" to the giver, and the roof of the porch exhibits, in like manner, a memento to John Mason and Catherine

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screen, was a favourite and often selected spot for burial.* Chaucer says in relation to it—

"He died when I came fro Hierusalem,
And lieth in grave onder the Rode-beem."

and this will account for such an one, independently of a probable desire to lie beneath the shelter of his own gift or good work, in the case of Gueman.

The exact date when Gueman flourished, or his donation here alluded to, is not recorded, but there is little doubt that it was, with the opposite screen on the south side, already completed in 1532, when the bequest of Mary Joye of the "two banner clothys," one for each of the chapels at the end of the aisles, was made; and this is further evidenced in the gift of 40*s.* in the same year "for a new coat for the good rood on the north side of the church" which appears then to have stood upon it.† To the making of the chancel screen £20 was given, as before suggested, in 1460. The age of the three screens, therefore, may be taken to be comprised within the period which elapsed between the latter year viz. 1460, and 1532, just mentioned.

The remaining object for notice as included among the painted decorations of this church, is the pulpit‡ just now referred to, which stands on the north side of the nave against the first column westward of the screens. This pulpit is, like the screens, covered with colour and gilding. It has unfortunately been subjected, within the last few years, to restoration, by which its ancient and corresponding appearance with the other and adjacent painted features is destroyed; the old patterns, however, have been carefully reproduced, and the colours as nearly as possible, so that for the purposes of a description, the following notes, taken while it yet remained in its original state, will apply, and sufficiently convey an idea of the nature and character of its decorations:—

In plan it is an octagon, elevated on a central shaft, also octagonal, from which spring groins to receive the increased diameter of the body; each face of which, based by a cornice above the groining, is panelled and filled with tracery, the angles having buttresses of two stages, the whole crowned by a moulded cornice filled in with flowers. The original stairs of ascent to it have been removed and a new staircase supplied. The old colouring of the central shaft was red; its cap has red and gold fillets with green hollows and main table. The panels of the groining are separated, each into three smaller panels, two in breadth of the upper part and one beneath; the grounds and hollows being in the one main division respectively red and green, and in the other main division green and red, the fillets and spandrel flowers of the tracery gilt, the panels studded with small flowers in black and gold. In the ribs of the groining, the hollows are white, enriched with red flowers with green stems and leaves, the fillets red, and the bead on the edge spirally banded black and gold. The cornice above the groining has its lower bead banded black and gold, its main hollow and upper slope green, fillet gold, and ogee red. The buttress faces are gilt, the sides red, the plinth of their bases red, and the hollow above these, as well as that of the pinnacle-cap at the middle stage, green. The panels of the body of the pulpit are treated in the same manner as those of the groining below, the grounds and hollows next them being alternately red and green, and green and red, powdered and enriched with gold and black flowers; the pattern varying in the grounds of the upper and lower subdivisions. The spandrel and other flowers in the cusp tions of the tracery at the foot of the smaller subdivisions or panelling, with the fillets between, are all gilt. The outer fillet round the main panels is green where the panelled ground is red, and red where green. The bead next this fillet is banded black and gold; the ogee next this bead, which forms the outer moulding, is green throughout, ornamented with small sized flowers at distances of about 6 inches apart. The outer fillet, or canted face, on which the buttresses are placed is white. The upper cornice, like the lower, has its under bead banded black and gold, its main hollow green, filled in with carved and gilt flowers, its fillet gold, and its upper slope red.

Such are the painted decorations yet remaining in the church of St. Edmund, Southwold, the effect of which in their original perfection, aided by

"The dim religious light
From storied window richly dight,"

and the other similar enrichments which formerly existed, must have been very rich and imposing. Though now standing as it were alone in this respect, they were anciently only features, evidently, of a general whole so decorated; existing remains showing that hardly a portion of the edifice, and particularly towards this part, was left undecorated in this way. On the roof of the north aisle traces of painting are still discernible. The nave roof also retains similar indications on the arch braces attached to the intermediate principals, and in other places; and it is probable that both, as well as that of the south aisle, and generally, though perhaps less profusely, throughout the church,* the same were exhibited, completing a full picture of what was once the common aspect and condition of our churches; one which for the sake of art, if for no other or higher motive, it might be well if we were to see again. Why, it may be well asked in the words of a talented author, or wherefore is it necessary, that "the soul should do penance through its eyes to keep alive our faith? The Almighty does not thus mortify our tastes. He spreads colour all over His creation for the special purpose of gratifying our vision. He connects its enjoyment with feeling, and thus makes it food for the soul." Divested of that which is calculated to religiously mislead, and denuded of erroneous representation, which was the object sought at the time of the reformation,† "colour," says the same authority, "is the type of holiness: if you doubt this, go to nature's sunsets, and then seek, through the endless variety of her beauty, to find from out of it a pleasure more pure and sincere than this." There is no aid more capable of creating religious sentiment or calculated better to convey such, or any other, information than a proper application of coloured and pictured representation. Such were the horn-books of religious instruction among our forefathers. Durandus calls pictures "the lessons, or scriptures, of the laity, or laic or unlearned, as distinguished from the cleric of his time;" and St. Gregory, with acute wisdom, remarks that "paintings appear to move the mind more than descriptions: for deeds are placed before the eyes in paintings, and so appear to be actually carrying on. But in description, the deed is done as it were by hearsay: which affecteth the mind less when recalled to memory." And again on the same point,—"what writing supplieth to him which can read, that doth a picture supply to him which is unlearned; speaking to the mind through the sense of sight." This principle is almost universally admitted and applied in other places: national galleries and museums are opened to foster a taste for and inculcate a knowledge among the million, to use a prevalent modern phrase, of worldly history, and the wonders of nature and art. Why should not the walls of our churches be devoted to the teaching by similar means of heavenly things? Thousands would look upon a picture, here displayed, who, if in respect to capability were competent, would be careless to read, or if they did would imbibe less readily the sacred events recorded in a less direct or enticing medium. The mistaken zeal of puritanism never did worse for religion than by so indiscriminately whitewashing our churches, while, artistically considered, the blow they gave has been a grievous and "a great discouragement" even to the present day; leaving our churches for the most part little better, and far less cared for as respects proper adornment and exposition of their purpose, than almost our meanest rooms. In fact, the dwellings of God lie waste in this respect, while we live in ceiled houses.

his wife. The font at Lound church, Suffolk, has a memorial inscription on its base. The vestry at Halesworth has an "orate" for Thomas Clement and Margaret his wife, who bore its cost. The hood-mould figures to the nave arches at St. Mary, Beverley, have scrolls or labels inscribed with the names of those who gave such arches; and there are numerous other instances.

* William Godell, another benefactor, and his wife, were also buried near to the rood screen (see Gardner's Hist. of Dunwich).

† Wake's Hist. Southwold, p. 254. The admission of this second rood in Southwold church, is curious as not usual in the smaller churches. The larger had occasionally more than one. Durham abbey church had four: one, described in the old authority as "the most famous rood in all the land," above the screen of Jesus altar, on the west side of the lantern, opposite the choir door; another at the east end of the south aisle of the choir, called "the Black rood of Scotland," taken from the Scots at the battle of Nevill's cross; a third at the east end of the north aisle of the choir; and the fourth at the west end of the south aisle of the nave, called "the Bonny rood." (See Sanderson's Rites of Durham.)

‡ As is the case with screens, there are several examples of the painted pulpit yet preserved in the churches of Norfolk and Suffolk; as well as a few in other counties. Castle-Acre has a painted pulpit, on the panels of which are represented the four doctors of the church. Harburton, near Totness, Devon, has one. Holme and Dartmouth churches in the same county also; and at Burlingham St. Andrew, Norfolk: a magnificent specimen is given in Blackburne's "Decorative Painting of the Middle Ages." Dollman in his "Ancient Pulpits" also gives some examples.

* The font, which stands at the south end of the nave, has evidently once been richly painted; the panels having had sculptured subjects, the whole of which have, however, been cut away. Something approaching to what it probably was may possibly be exhibited in the neighbouring church of Westall, where a very interesting and highly enriched font retaining its original painted decoration yet remains in comparatively fair condition.

† "The object of our reformers," says the Rev. J. Pindar in his 'Sermons on the Common Prayer,' "was not to banish indiscriminately everything which had belonged to the church while under the power of Rome in this country. They would not cut away that which might be preserved and healed; they removed only those errors which had arisen from neglect of scripture and disregard to the traditional interpretation of the primitive church."—It was the after fanaticism that originated the permitted jubilee of the whitewash brush.

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ON THE DYNAMICS OF A RIGID BODY.

By ARTHUR COHEN, B.A., Magd. Coll. Camb.

§ 1. In the following paper I propose to extend to the dynamics of a rigid body the principles and method which I developed in the last number of this Journal, and there applied to the dynamics of a particle. The only additional mechanical principle that is required is D'Alembert's principle; but in order to enunciate this principle clearly and concisely it is convenient to premise a few definitions, and to make a few observations connected with statics and the dynamics of a particle.

§ 2. For reasons stated in the preceding paper I shall denote by the complete sum or difference of two forces acting at one point, the force which is represented by the complete sum or difference of the lines representing those two forces; and similarly I shall denote by the complete sum or difference of two couples, the couple whose axis is the complete sum or difference of the axes of the two couples.

If G be the axis of a couple, I shall call that couple the couple G. If P and Q be forces acting at the same point, I shall denote their complete sum or difference by (P)+(Q). And if G and H be the axes of two couples, I shall denote the complete sum or difference of the couples G and H by (G)+(H).

Suppose further a point P to act at a point m of a rigid body, and O to be some definite point: then by putting on at O equal and opposite forces P and −P, we see that P at m is equivalent to P at O, and the couple (−P, Om, P). Let the axis of this couple be G: then P at m is equivalent to P at O and the couple G. Similarly, if Q be another force acting at n, then Q at n is equivalent to Q at O and a couple H. Therefore the resultant of P at m and Q at n is (P)+(Q) at O and a couple (G)+(H). Again, it is clear that the resultant of P at m and a force (−Q) at n is, [(−Q) being equal and opposite to Q,] (P)−(Q) at O and a couple (G)−(H).

It is easy then to see, how it is convenient by way of analogy to call the resultant of P at m and Q at n the complete sum of those forces, and to call the resultant of P at m and (−Q) at n the complete difference of the forces P at m and Q at n.

Similarly, I shall call the resultant of two sets or systems of forces P P'... and Q Q'..., the complete sum of those systems; and I shall call the resultant of the two systems of forces P P'..., (−Q) (−Q')..., the complete difference of the systems P P'..., Q Q'...

§ 3. I will now proceed to dynamical considerations.

The momentum of a particle in motion is the product of its mass and velocity, and its direction is that of the velocity. It may therefore be completely represented by a straight line.

An impulsive force acting on a particle at rest is measured by, and may be said to be equal to the momentum it generates in that particle, and is in the direction of that momentum: it is therefore completely represented by the line which represents the momentum.

If an impulse acts on a particle in motion it produces its full effect, just as if the particle were at rest, so that the velocity which the particle will have after the impulse is compounded of the former velocity and the velocity which the impulse would generate in the particle were it at rest.

Whence it follows, that an impulsive force acting on a particle in motion is represented by or is the complete difference of the momenta before and after the action of the impulse; or, more briefly, an impulsive force is the complete increment of the momentum of the particle.

§ 4. Suppose in the next place a rigid body to be acted on by impulsive forces (which forces are called the impressed forces), then that impulse under which a particle if free would move, as it actually does, is called the effective force belonging to the particle, and is therefore the complete increment of the particle's momentum.

Now D'Alembert's principle, as applied to impulsive forces, asserts that the effective forces belonging to the several particles of a rigid body are statically equivalent to the impressed forces.

Let then mv, m_1v_1, m_2v_2..... denote both in direction and magnitude the momenta of the particles m, m_1..... before the action of the impulses, and let mv', m_1v_1'..... denote the same after the action of the impulses; then according to D'Alembert's principle the impressed forces are eq ivalent to the system

$$[(mv')-(mv)]+[(m_1v_1')-m_1v_1], \text{ \&c.}$$

and therefore the impressed forces are equivalent to the resultant of the two following systems: the system

$$(mv') + (m_1v_1') + \ldots\ldots$$

and the system

$$(-mv) + (-m_1v_1) + \ldots\ldots$$

Therefore, by section 2, the impressed forces are equivalent to the complete difference of the two last-mentioned systems of momenta, or, more briefly, to the complete increment of the system of momenta of the body's particles.

§ 5. The system of momenta is of course by statics reducible to a single momentum at some point O, and a couple of momenta; and in order to avoid useless repetition we shall throughout this essay denote that single momentum by F, and the axis of that couple of momenta by Q. So that the system of momenta of a body's particles is equivalent to what I shall call the body's single momentum F at O, and the body's momentum couple Q.

Let F_x F_y F_z be the components of F parallel to the co-ordinate axes of x y z.

Let Q_x Q_y Q_z be similarly the components of Q.

Let F F_x ....., Q Q_x ..... have reference to the body before the action of the impulses, and let the impulses change these magnitudes into F' F'_x ... .., Q' Q'_x .....

Let further the impressed forces be reduced to a force P at O, and a couple G.

Let the components of P be P_x P_y P_z, and those of G be G_x G_y G_z.

We have then, according to the last section, P=(F')−(F), and G=(Q')−(Q); and therefore, by an easy proposition in the preceding paper in this Journal, it follows that

$$P_x = F'_x - F_x \qquad G_x = Q'_x - Q_x$$
$$P_y = F'_y - F_y \qquad G_y = Q'_y - Q_y$$
$$P_z = F'_z - F_z \qquad G_z = Q'_z - Q_z$$

§ 6. As these formulæ are very important, I will show how they may be easily deduced in a different way.

Let u v w be the components, parallel to the co-ordinate axes, of a particle of mass m, before the action of the impulsive forces, and let u' v' w' be what the same magnitude becomes after the action of the impulses.

Then by definition the components of the effective force belonging to m are

$$m(u'-u) \qquad m(v'-v) \qquad m(w'-w), \text{ all acting at } m.$$

We have similar expressions for the other particles m'..... of the body. By D'Alembert's principle, and by applying the ordinary formulæ of statics, we obtain

$$P_x = \Sigma m(u'-u) = \Sigma(mu') - \Sigma(mu).$$

Therefore, using the notation of the preceding section,

$$P_x = F'_x - F_x .$$

Again, we obtain in the same way,

$$G_x = \Sigma m[(w'-w)y-(v'-v)z]$$
$$= \Sigma m(w'y-v'z) \quad -\Sigma m(wy-vz)$$

But $Q'_x = \Sigma m(w'y-v'z)$, and $Q_x = \Sigma m(wy-vz)$.

Therefore $G_x = Q'_x - Q_x$.

Thus we obtain the formulæ in the last section, and we might therefrom deduce P=(F')−(F), and G=(Q')−(Q), which shows as before, that the impressed impulses are equivalent to the complete increment of the system of momenta of the body.

§ 7. Let us now take the case of a body acted on by finite accelerating forces or pressures.

In this case the effective force belonging to a particle of the body is equal to the product of the particle's mass and its acceleration, and is in the direction of its acceleration. It is therefore, according to the paper above referred to, the complete differential coefficient of the particle's momentum.

Now D'Alembert's principle asserts that the impressed forces are statically equivalent to the effective forces belonging to the several particles of a body which is acted on by these impressed forces.

§ 8. It is now time to observe, that just as I spoke of the complete increment of a system of momenta, so may I speak of the complete differential co-efficient of such system. For the system is reducible to a single momentum F at O, and a couple whose axis is Q; F and Q being represented by straight lines.

If we then consider the system, which is equivalent to a single momentum D_t (F) at O, and a couple whose axis is D_t (Q), such system will by analogy be called the complete differential coefficient of the former system; and the couple whose axis is D_t (Q)

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will be called the complete differential coefficient of the couple whose axis is Q.

§ 9. Now if we were to proceed step for step, as we have done in the earlier sections of this paper, we might prove that D'Alembert's principle is equivalent to the following proposition:

"The impressed forces are equivalent to the complete differential coefficient of the system of the momenta of the particles of a body."

But as this is a very important proposition, I will prove it in a different way.

Let F, Q, F_x, &c., Q_x, &c., denote what they did in secs. 5 and 6.

Let the impressed forces be reducible to P at O and a couple G.

Let P_x P_y P_z be the components of P.

„ G_x G_y G_z „ „ G.

Let (xyz) be the co-ordinates of mass m; then the components of the effective forces belonging to m are

$$m\frac{d^2x}{dt^2} \qquad m\frac{d^2y}{dt^2} \qquad m\frac{d^2z}{dt^2}$$

and similarly the effective forces belonging to m' are

$$m'\frac{d^2x}{dt^2} \qquad m'\frac{d^2y}{dt^2} \qquad m'\frac{d^2z}{dt^2}$$

and so on for the other particles.

These are by D'Alembert's principle equivalent to the impressed forces. Therefore by the ordinary formulæ of statics, we have

$$P_x = \Sigma m\left(\frac{d^2x}{dt^2}\right) = \frac{d}{dt}\,\Sigma\left(m\frac{dx}{dt}\right)$$

$$G_x = \Sigma m\left(y\frac{d^2z}{dt^2} - z\frac{d^2y}{dt^2}\right) = \frac{d}{dt}\,\Sigma m\left(y\frac{dz}{dt} - z\frac{dy}{dt}\right)$$

But clearly, $m\frac{dx}{dt}$ is the component of the momentum of the particle m. Therefore $\Sigma m\left(\frac{dx}{dt}\right)$ equals what we denoted by F_x, and $\Sigma m\left(y\frac{dz}{dt} - z\frac{dy}{dt}\right)$ = what we denoted by Q_x. Therefore,

$$P_x = \frac{d}{dt}(F_x). \quad \text{Similarly, } P_y = \frac{d}{dt}(F_y),\ P_z = \frac{d}{dt}(F_z)$$

$$G_x = \frac{d}{dt}(Q_x) \qquad „ \qquad G_y = \frac{d}{dt}(Q_y),\ G_z = \frac{d}{dt}(Q_z)$$

Therefore, by an easy proposition in the preceding paper in this Journal, the resultant of P_x P_y P_z or P equals the complete differential coefficient of the resultant of F_x F_y F_z or of F. Or,

$$\therefore\ P = D_t(F), \quad \text{similarly, } G = D_t(Q).$$

And therefore, by definition, P at O and the couple G are equivalent to the complete differential coefficient of F at O and the couple Q. That is to say, the impressed forces are equivalent to the complete differential coefficient of the system of momenta of the body's particles.

§ 10. I will now just recapitulate the notation I shall constantly use.

The momenta of the particles of a body may be, if compounded as forces, reduced to a single momentum at a point O, and a couple of momenta. The former I call the body's single momentum, and shall always denote by F; the latter I call the body's momentum couple with reference to O, and shall denote its axes by Q. F and Q may then be said to represent straight lines. It is to be observed that F is the same wherever we take O, but Q changes with the position of O. O may be called the point of reference, and Q the body's momentum couple with reference to O. I shall always denote the components of F parallel to the co-ordinate axes by F_x F_y F_z, and those of Q by Q_x Q_y Q_z.

Let then the forces acting on a body be reduced to a force P at O and a couple G. Then in the case of a body acted on by impulsive forces, we have deduced from D'Alembert's principle that P equals the complete increment of F, and G equals the complete increment of Q; or,

$$(F')-(F) = \Delta(F) = P; \qquad (Q')-(Q) = \Delta(Q) = G.$$

In the case of a body acted on by finite accelerating forces, we have deduced from D'Alembert's principle that

P = the complete differential coefficient of F,

G = „ „ „ Q,

or, $D_t(F) = P$; „ $D_t(Q) = G$.

I proceed now to find the expressions for F and Q.

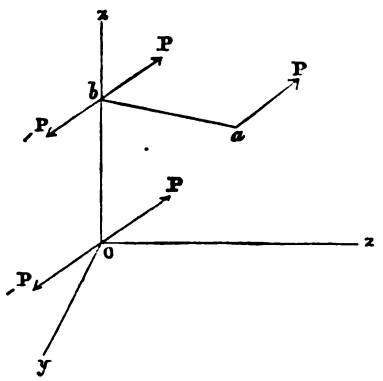
§ 11. First take the case of a body having simply a motion of translation. Let M be the body's mass, and let the velocity of the motion of translation be v in direction Ox. Then the momentum of any particle of mass m is mv in direction Ox. So that the system of momenta of the particles is a system of forces which are parallel to Ox, and which are respectively proportional to the masses of the particles at which they act. The resultant is therefore the sum of the momenta applied at the centre of gravity of the body. That sum is $v\Sigma m$ or Mv. Therefore, using the notation of the last section, we find that if we take the centre of gravity as the point of reference, then

$$F = Mv. \qquad Q = O.$$

In other words the momenta system is equivalent to the body's single momentum acting at the centre of gravity.

§ 12. Let us next take the case of a body of mass M revolving about a fixed line with angular velocity ω.

Let Oz be the fixed line, which take for axis of z. Let Ox, Oy be lines at right angles to Oz and to one another, and take them for axes of x and y. Let m be the mass of a particle whose co-ordinates are x, y, z, and whose distance from Oz is $ab = r$.



Then the momentum of the particle m at a is clearly $m\omega r$ in direction perpendicular to ab and Oz, and therefore perpendicular to the plane zOa.

We might now find the resultant of the momenta system, as is usually done, by the ordinary analytical formulæ of statics; but the following direct method is more satisfactory:

Let the momentum $m\omega r$ be denoted by P. At b and O apply equal and opposite forces P and —P. Then we at once see that P at a is equivalent to P at O and two couples, namely, a couple (—P, ba, P) whose axis is equal to $Pr = m\omega r^2$ and is in direction Oz, and a couple (—P, bO, P) whose moment is Pz or $m\omega rz$, and whose axis being perpendicular on the plane of the couple, is evidently in direction opposite to ba. Since now the line ba is compounded of x and y, it follows that the axis of the latter couple is compounded of axes $-m\omega xz$ parallel to Ox, and $-m\omega yz$ parallel to Oy. Whence, collecting these results, we see that P at a is equivalent to P at O, and three couples, whose axes are respectively $m\omega r^2$ along Oz, $-m\omega xz$ along Ox, $-m\omega yz$ along Oy.

And therefore, using the notation of section 10, the body's momentum couple C with reference to O the origin of co-ordinates is compounded of

$$Q_z = \omega\Sigma(mr^2), \quad Q_x = -\omega\Sigma(mxz), \quad Q_y = -\omega\Sigma(myz)\ldots \qquad \ldots(I.)$$

§ 13. I shall assume here the well known properties of principal axes. If then Oz be the principal axis at O, we have

$$\Sigma(mxz) = O \qquad \Sigma(myz) = O$$

$$\therefore\ Q_x = O \qquad Q_y = O.$$

Therefore the body's momentum couple is simply

$$Q_z = \Sigma(mr^2)\omega = \omega Mk^2,$$

Mk^2 being the moment of inertia about Oz.

We have then the following proposition, which gives to principal axes their very great mechanical importance, and might perhaps properly be made the foundation of their definition:

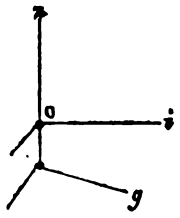
"If a body is rotating about a principal axis, in such case, and in no other case, is the body's momentum-couple with reference to any point on the axis perpendicular on the axis of rotation.

§ 14. To find the body's single momentum F, we have merely to collect the momenta at O. Now the momentum $m\omega r$ being parallel to the plane of xy, and perpendicular on ba, is equivalent

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to $-m\omega y$ parallel to Ox, and $m\omega x$ parallel to Oy. Therefore the body's single momentum F is compounded of

$$F_x = -\omega\Sigma(my), \qquad F_y = +\omega\Sigma(mx).$$



Let g be the body's centre of gravity. Let $x_1\ y_1\ z_1$ be the co-ordinates of g. Draw gh perpendicular on Oz, and hi perpendicular on the plane z_1Og. Let $gh = r_1$; then evidently

$$F_x = -\omega My_1 \qquad F_y = +\omega Mx_1 \ \ldots \ (II.)$$

Therefore F the resultant of F_x, F_y is $M\omega r_1$ in direction parallel to hi, and is therefore the momentum of a particle of mass M moving in the place of the centre of gravity.

If the centre of gravity lies in Oz, it follows from the above that F=0, and the body's momentum system is simply a couple.

§ 15. Thus we have proved that the system of momenta due to a motion of rotation about a principal axis is equivalent to a momentum couple (perpendicular on that axis, and the moment of which is the product of the angular velocity into the moment of inertia about the axis), together with a momentum which would be the momentum of the centre of gravity if the body's mass were there collected, such momentum acting at the point where the axis is a principal axis.

§ 16. Having now investigated the momenta system of a body, due to a simple motion of translation and to a simple motion of rotation, I shall proceed to show how from these results we can deduce the resultant of the momenta of the particles of a body which moves in any manner whatsoever.

§ 17. A body's motion is said to be compounded of motions $\alpha\beta\gamma$; if the velocity of each particle of the body is the resultant of the velocities due to the motions $\alpha\beta\gamma$ separately, that is to say, of the respective velocities which the particle would have if the body had only the motion α, only the motion β, only the motion γ. In such case then the momentum of a particle will be the resultant of the momenta due to each of the motions $\alpha\beta\gamma$; and since the resultant of forces is the same in whatever way we group them together, we see at once the truth of the following very useful proposition:—

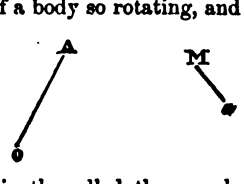
"The resultant of the momenta of the body's particles, or what I have called the momenta system of the body, is the resultant or complete sum of the momenta systems due to each of the motions $\alpha\beta\gamma$."

§ 18. In the next place I will prove the principle of the composition of motions of rotation.

A motion of rotation about an axis with angular velocity ω is completely represented by a line equal in magnitude to ω and in the direction of the axis about which the body rotates. Such line is called the axis of rotation. Now the principle of the composition of angular velocities of rotation asserts, that motions of rotation are compounded by compounding their respective axes of rotation.

From the preceding section it is clear, that this principle simply amounts to saying, that the linear velocity of any particle M of a rigid body due to a motion of rotation is the resultant of the linear velocities due to the motions of rotation into which the former motion of rotation can be decomposed. And as the linear velocity of M due to a rotation which is represented by its axis OA is a line which is perpendicular on the plane containing OA and M, and which is equal to OA into the distance of M from OA, it follows that the principle in question is simply a geometrical proposition. Its truth may be easily proved by the ordinary formulæ of geometry of three divisions, but it becomes at once evident from a consideration which enables us to solve immediately all the problems of the composition of motions of rotation.

§ 19. Let OA represent a motion of rotation about OA with angular velocity OA; in fact, let OA be the axis of rotation, as above defined. Let M be any particle of a body so rotating, and let $M\alpha$ be the linear velocity of M due to the rotation represented by OA. Then $M\alpha$ is equal to OA into its perpendicular distance from M, and is perpendicular on the plane MOA. Now if OA represented a force, OA at O would be equivalent to OA at M and a couple, which couple may be conveniently called the couple



engendered by transferring OA to M. And it is clear that the axis of that couple would be $M\alpha$.

We see therefore, that the linear velocity of M due to a rotation of which OA is the axis, is the axis of the couple engendered by transferring a force OA to M.

§ 20. If therefore we have any number of motions of rotations about different axes, the resultant of the linear velocities due to each of such rotations will be the resultant or complete sum of the axes of the couples which are respectively engendered by transferring the respective axes of rotation to M, and will therefore be the axis of the couple engendered by transferring to M the resultant of these axes of rotation, just as if they were forces. If then we have two given axes of rotation, OA, OB, the linear velocity of M due to the rotation compounded of the two given rotations will be the axis of the couple engendered by transferring to M, OC, which is the diagonal of the parallelogram constructed on OA and OB, and will be therefore the linear velocity due to a rotation represented by OC.

Whence the required proposition is proved.

§ 21. If we wish to find the resultant of opposite and equal motions of rotation about axes OA and O'A', we have simply to transfer those lines, as if they were forces, to M, which can be done by transferring the couple which the axes OA, O'A' themselves constitute; and we therefore find that the linear velocity of M due to the motion compounded of the two equal and opposite rotations is the axis of that couple; it is therefore perpendicular on its plane, and is equal to the moment of the couple. The linear velocity of M being thus the same in magnitude and direction for all particles of the body, it follows that two equal and opposite motions of rotation about different axes are equivalent to a motion of translation.

§ 22. The results of these two last sections may therefore be summed up in the following proposition:

"Motions of rotation about different axes may be compounded and transferred from one point to another, by compounding and transferring the axes representing those rotations, just as if those axes were forces, and every couple of equal and opposite axes corresponds to a motion of translation which is represented by the axis of such couple."

Let us now take the case of a body moving about a fixed point. I shall assume the proposition that if a body is moving about a fixed point it must at any instant be rotating about some one line through the fixed point. It follows then from the preceding section that that motion can be decomposed into three rotations about any three axes whatever. Take the principal axes at the fixed point for co-ordinate axes. Let the body's motion be decomposed into rotations about those axes with angular velocities ω_x, ω_y, ω_z respectively. Let A, B, C be the moments of inertia about the principal axes respectively.

According to section 17 the momenta system of the body is equivalent to the resultant of the momenta systems due to the rotation about ω_x, ω_y, ω_z respectively; and is therefore by sec. 13 equivalent to three momentum couples whose axes are $A\omega_x$, $B\omega_y$, $C\omega_z$ respectively perpendicular on Ox Oy Oz, together with three momenta.

Therefore, using the notation of section 10, we have

$$Q_x = A\omega_x \qquad Q_y = B\omega_y \qquad Q_z = C\omega_z$$

§ 24. To find the single momenta, let us remember, that if OA be the axis about which the body is rotating, and v be the velocity of the centre of gravity, then section 14 shows us that the body's single momentum F is Mv in direction of v. But we know from the preceding paper in this Journal, that, if v be the velocity of a point $x_1\ y_1\ z_1$, which is turning about three axes with angular velocities $\omega_x\ \omega_y\ \omega_z$, then the components of v are

$$z_1\omega_y - y_1\omega_z \qquad x_1\omega_z - z_1\omega_x \qquad y_1\omega_x - x_1\omega_y.$$

Therefore the components of F are

$$F_x = M(z_1\omega_y - y_1\omega_z), \quad F_y = M(x_1\omega_z - z_1\omega_x), \quad F_z = M(y_1\omega_x - x_1\omega_y)$$
$$F_x = Mv_x \qquad F_y = Mv_y \qquad F_z = Mv_z \ \ldots \quad \ldots (I.)$$

v_x, v_y, v_z being the components of v.

§ 25. Having now investigated the momenta system of a body for these cases of motion, it is extremely easy, by applying the propositions to which in section 10 we reduced D'Alembert's principle, and by making use of the fundamental propositions concerning the complete differential coefficients of lines, to deduce all the formulæ of the dynamics of a rigid body, whether for impulsive or accelerating forces.

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Let us first take the case of a body turning about a fixed axis under the action of given impulsive forces. Let the given impulses be reduced to

$$X, Y, Z \text{ at O and couples } L_x L_y L_z \quad \ldots \quad \ldots \quad (1)$$

Let the reactions of the fixed axes be reduced to

$$X', Y', Z' \text{ at O and couples } L'_x L'_y \quad \ldots \quad \ldots \quad (2)$$

for clearly the reactions have no moment about the axis of Z, which I take for the fixed axis. The sets (1) and (2) constituted the impressed forces. Let ω be the angular velocity of rotation before the action of the impulses, and let these change the angular velocity into ω'. I shall use the notation in section 10.

Looking at the formulæ (I.) and (II.) in sections 12 and 14, it is clear that F' is what F becomes when for ω we put ω', and that (F')—(F) is deducible from F by putting for ω, $\omega'-\omega$. Applying then the formulæ of sections 5 and 12 and 14, we find at once,

$$\begin{aligned}
X+X' &= -(\omega'-\omega)My_1 \quad \ldots \quad \ldots \quad (1)\\
Y+Y' &= +(\omega'-\omega)Mx_1 \quad \ldots \quad \ldots \quad (2)\\
Z+Z' &= 0 \quad \ldots \quad \ldots \quad \ldots \quad (3)\\
L_x+L'_x &= -(\omega'-\omega)\Sigma(mxz) \quad \ldots \quad (4)\\
L_y+L'_y &= -(\omega'-\omega)\Sigma(myz) \quad \ldots \quad (5)\\
L_z &= (\omega'-\omega)Mk^2 \quad \ldots \quad \ldots \quad (6)
\end{aligned}$$

L_z is the moment of the given forces about Oz the fixed axis, and the last equation shows that the increment of the angular velocity =the moment of the given forces about the fixed axis divided by the moment of inertia. The form and constitution of the body give us $\Sigma(mxz)$ and $\Sigma(myz)$, and therefore the couples L'M' become known by equations (4) and (5); and the three other formulæ give the components of the reactions of the axis.

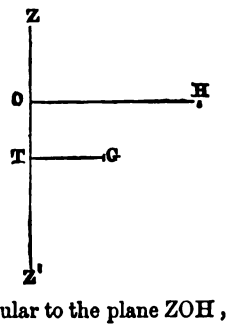
§ 26. I will now deduce the properties of the centre of percussion, because in the ordinary books—such as Griffin's and Pratt's Mechanics—they are proved in a very cumbrous and unsatisfactory manner.

It is then required to find under what circumstances, if any, the fixed axes will receive no impulse by reason of an impulse applied to the body at rest. It follows from D'Alembert's principle, as stated in section 10, that this can only happen when the impressed force is itself equal to the complete increment of the momenta system; or as the body is supposed to be originally at rest, the impressed force must be equivalent to the resultant of the momenta system after the impulse. If ω be the angular velocity imparted by the impulse, we have proved in section 14 that the body's single momentum is $M\omega r_1$ perpendicular to the plane containing *Oz* and the centre of gravity. Now the impulse must be equal and parallel to the body's single momentum; it must be therefore perpendicular to the plane containing the centre of gravity and Oz. Take then that direction as the direction of the axis of *y*, and denote the impulse by Y; and take the origin of co-ordinates, so that the plane of *xy* shall contain the direction of the impulse. By so doing we shall have contrived to make the impulse have no moments about the axis of *y* or of *x*, and therefore the body's momentum couples perpendicular to the axes of *x* and *y* must be zero. Therefore, by section 15, the fixed must be a principal axis at the origin of co-ordinates, which point is the point in which the axis is met by a plane perpendicular to it and containing the direction of the impulse.

Finally, if *a* be the distance of the impulse Y from Oz, the couple about Oz to which it gives rise has Y*a* for its moment, and this must equal the body's momentum couple $Mk^2\omega$. But we have shown that $Y=M\omega r_1$, or

$$a = \frac{k^2}{r}$$

To find then the centre of percussion, or the part at which the impulse must be applied, proceed as follows:



Let ZZ' be the fixed axis; G the body's centre of gravity. ZZ' must be a principal axis at some point, or else there is no centre of percussion: let that point be O. At O in the plane through ZZ' and G draw OH perpendicular to OZ and equal to $\frac{k^2}{r_1}$, where k^1 is the radius of gyration about ZZ', and r_1 is GT, the perpendicular distance of G from ZZ'. Then we have proved that if the body be struck at H in direction perpendicular to the plane ZOH, the axis will receive no impulse. Therefore, the line through H in the direction perpendicular to ZOH is the locus of the centres of percussion. Therefore, the only necessary condition for the existence of a centre of percussion is, that the fixed axis be a principal axis, and that the centre of gravity do not lie in the axis.

§ 27. I will now take the case of a body turning about a fixed axis, and acted on by given finite accelerating forces.

Let ω be the angular velocity of rotation at time *t*.

Let the given forces be reduced to XYZ at O and couples $L_x L_y L_z$.

Let the reactions of the axis be reduced to X' Y' Z' at O and couples $L'_x L'_y$.

In this case we take for co-ordinates Oz the fixed axis and two lines Ox, Oy that move with the rigid body. I shall use again the notation of section 10. As the axis of *z* does not vary in direction, it follows from the preceding paper in this Journal, that the complete differential coefficient of $F_z = D_t(F_z)$ is $\frac{d}{dt}(F_z)$ in direction Oz. Similarly, $D_t(Q_z) = \frac{d}{dt}(Q_z)$ in direction Q_z.

The axes of *x* and *y* are variable in position; they turn in the plane of *xy* with an angular velocity ω. Therefore, by the preceding paper the complete differential coefficient of B_x and B_y is

$$\frac{d}{dt}(F_x) - F_y\omega \text{ parallel to } Ox.$$

and

$$\frac{d}{dt}(F_y) + F_x\omega \text{ parallel to } Oy.$$

Similarly, the complete differential coefficient of C_x and C_y is

$$\frac{d}{dt}(Q_x) - Q_y\omega \text{ parallel to } Ox,$$

and

$$\frac{d}{dt}(Q_y) + Q_x\omega \text{ parallel to } Oy.$$

We have then simply to substitute for F_x, &c. Q_x, the values obtained in sections 12 and 14, and to apply the fundamental formulæ of section 10. We thus obtain:

$$\begin{aligned}
X+X' &= -My_1\frac{d\omega}{dt} - M\omega^2 x_1\\
Y+Y' &= +Mx_1\frac{d\omega}{dt} - M\omega^2 y_1\\
Z+Z' &= 0,\\
L_x+L'_x &= -\frac{d\omega}{dt}\Sigma m(xz) + \omega^2\Sigma m(yz)\\
L_y+L'_y &= -\frac{d\omega}{dt}\Sigma m(yz) - \omega^2\Sigma m(xz),\\
L_z &= Mk^2\frac{d\omega}{dt}
\end{aligned}$$

We thus see the full import of these equations. The right-hand sides are merely the components of the complete differential coefficients of the momenta system; the first two constituting together the complete differential coefficients of F_x and F_y: the fourth and fifth constitute the complete differential coefficient of Q_x and Q_y, and the sixth is the differential coefficient of Q_z.

§ 28. Let us now investigate under what circumstances there will be no pressure on the axis, supposing no forces to act on the body.

In order to show the use of the method I have adopted, I shall, just as I did in discussing the centre of percussion, avoid all analytical formulæ, and deduce the result from fundamental principles. Since there are no impressed forces, it follows that the complete differential coefficient of the body's single momentum and of the body's momentum couple must be zero. Therefore, the body's single momentum must be of constant magnitude and of constant direction. And similarly with respect to the momentum couple. Both F and Q are therefore each of constant magnitude and direction.

Therefore, the component of Q parallel to the fixed line Oz must be constant. Therefore Q_z is constant. But $Q_z = Mk^2\omega$ $\therefore$ ω is constant.

Again, the component of Q in direction perpendicular to Oz must be constant. Therefore $(Q_x)+(Q_y)$ must be constant in magnitude and direction.

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Now in section 12 we found,

$$Q_x = -\omega\Sigma(mxz)$$
$$Q_y = -\omega\Sigma(myz)$$

As ω is constant, both Q_x and Q_y are constant. Unless then they both were zero their resultant would vary with the axes of x and y, which by hypothesis move with the body.

$$\therefore\ Q_x = 0 \qquad Q_y = 0$$
$$\therefore\ \Sigma(mxz)=0, \text{ and } \Sigma(myz)=0.$$

that is to say, the fixed axis must be a principal axis. Similarly, it follows that

$$F_x = 0, \text{ and } F_y = 0$$

But $F_x = -M\omega y_1$, $F_y = M\omega x_1$. $\therefore\ y_1=0$, $x_1=0$.

Therefore in order that there be no pressure on the axis, that axis must be a principal axis, and must pass through the centre of gravity.

§ 29. I will now take the case of a body revolving about a fixed point O under the action of impulsive forces. Take the principal axes at O for co-ordinate axes, as in section 23. Let $\omega_x\ \omega_y\ \omega_z$ be angular velocities about the axes before the action of the impulses, and let them become $\omega'_x\ \omega'_y\ \omega'_z$ afterwards.

Then from section 23 it is clear that

$$\Delta(Q_x)=A(\omega'_x-\omega_x)$$
$$\Delta(Q_y)=B(\omega'_y-\omega_y)$$
$$\Delta(Q_z)=C(\omega'_z-\omega_z)$$

Let now X'Y'Z' be the reactions of the axis.

Let the given impulses be reduced to X Y Z at O, and couples $L_x\ L_y\ L_z$.

Then by the fundamental formulæ of section 10 we have

$$L_x=A(\omega'_x-\omega_x) \quad L_y=B(\omega'_y-\omega_y) \quad L_z=C(\omega'_z-\omega_z).$$

Moreover it is clear that $\Delta(F_x)$ will be found from F_x by putting for ω_x, $\omega'_x-\omega_x$.

Therefore, looking at formula (I.) of section 24, and putting

for $\omega'_x-\omega_x$ its value $\frac{L_x}{A}$

for $\omega'_y-\omega_y$ its value $\frac{L_y}{B}$

for $\omega'_z-\omega_z$ its value $\frac{L_z}{C}$

we obtain $X+X'=M\left(z_1\frac{L_y}{B}-y_1\frac{L_z}{C}\right)$ &c.

§ 30. I will now take the case of a body moving about a fixed point O, and acted on by given finite accelerating forces.

Let the given forces be reduced to XYZ at O, and couples $L_x\ L_y\ L_z$.

Let the reaction of the fixed point be X'Y'Z' at O.

Now it is clear from section 10 that we have to take the complete differential coefficient of

$$F = (F_x)+(F_y)+(F_z),$$

and of

$$Q = (Q_x)+(Q_y)+(Q_z).$$

Here the axes are variable in position, for we suppose them to be the principal axes which move with the body.

From the formulæ in my preceding paper in this Journal, it follows that the complete differential coefficient of Q has for its components

$$\frac{d}{dt}(Q_x)+Q_z\omega_y-Q_y\omega_z \text{ parallel to } Ox$$
$$\frac{d}{dt}(Q_y)+Q_x\omega_z-Q_y\omega_x \quad ,, \quad Oy$$
$$\frac{d}{dt}(Q_z)+Q_y\omega_x-Q_z\omega_y \quad ,, \quad Oz.$$

But we have found

$$Q_x=A\omega_x, \quad Q_y=B\omega_y, \quad Q_z=C\omega_z.$$

Therefore we have

$$L_x=A\frac{d\omega_x}{dt}+(C-B)\omega_y\omega_z$$
$$L_y=B\frac{d\omega_y}{dt}+(A-C)\omega_z\omega_x$$
$$L_z=C\frac{d\omega_z}{dt}+(B-A)\omega_x\omega_y$$

which are Euler's celebrated formulæ.

Exactly in the same way we find for the components of the complete differential coefficient of F.

$$\frac{d}{dt}(F_x)+F_z\omega_y-F_y\omega_z=X+X', \text{ &c.}$$

and for $F_x\ F_y\ F_z$ we might substitute their values from sections 27 or 24.

§ 31. It is extremely useful to consider Euler's formulæ as nothing but the components parallel to the principal axes of the complete differential coefficient of the line whose components are $A\omega_x$, $B\omega_y$, $C\omega_z$. Indeed, most problems about a body moving round a fixed point O can be solved best by simply considering, that if we reduce the impressed forces to a force O and a couple whose axis is G, then G is the complete differential coefficient of a line Q, whose projection on the principal axes at O are $A\omega_x$, $B\omega_y$, $C\omega_z$.

§ 32. Take for instance the case of no forces whatever acting on the body.

G is zero: therefore the complete differential coefficient of Q is zero. Therefore Q is a line Oq of constant direction and magnitude; and the whole nature of the body's motion must be deducible from the fact, that the body is revolving with angular velocities ω_x, ω_y, ω_z about principal axes, which move in such a way, that there is a certain fixed line Q whose projections on those axes are $A\omega_x$, $B\omega_y$, $C\omega_z$. Since Q is constant in magnitude, we have $Q^2=A^2\omega_x^2+B^2\omega_y^2+C^2\omega_z^2=$ a constant, say k^2.

§ 33. I have shown in a former paper that the complete differential coefficient of a line Q is made up of

$\frac{dQ_x}{dt}$ parallel to Ox, $\frac{dQ_y}{dt}$ parallel to Oy, $\frac{dQ_z}{dt}$ parallel to Oz,

and a line perpendicular to the axis about which the co-ordinate axes are revolving.

Therefore if Q is constant the resolved part of

$\left(\frac{dQ_x}{dt}\text{ parallel to }Ox,\ \frac{dQ_y}{dt}\text{ parallel to }Oy,\ \frac{dQ_z}{dt}\text{ parallel to }Oz\right)$

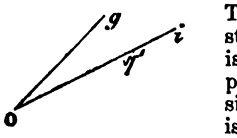
along the instantaneous axis, must be zero.

Therefore, if $\omega=\sqrt{\omega_x^2+\omega_y^2+\omega_z^2}$, we have

$$\frac{d}{dt}(A\omega_x)\frac{\omega_x}{\omega}+\frac{d}{dt}(B\omega_y)\frac{\omega_y}{\omega}+\frac{d}{dt}(C\omega_z)\frac{\omega_z}{\omega}=0$$
$$\therefore\ A\omega_x^2+B\omega_y^2+C\omega_z^2=\text{a constant, say } h^2.$$

Let now ϕ equal the angle between the instantaneous axis Oi and the line Q or Oq. Then

$$\cos\phi=A\omega_x\frac{\omega_x}{\omega}+B\omega_y\frac{\omega_y}{\omega}+C\omega_z\frac{\omega_z}{\omega}=\frac{h^2}{\omega}$$



Take now a distance $Op=$ to ω on the instantaneous axis. Then $Op\cos\phi=\omega\cos\phi$ is constant $=h^2$. Oq is the normal to a plane which is called invariable, because since Oq is fixed, the direction of the plane is also fixed.

From the above Perrisot's illustration of the motion of the body may be easily deduced, as they are deduced in page 47 of Griffin's Dynamics.

GLASGOW ARCHITECTURAL SOCIETY.

At the opening meeting of the session of the Glasgow Architectural Society, the following address was delivered by Professor W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

"I cannot but feel grateful for the great honour which the council of this society have done me in requesting me to speak on the present occasion. At the same time I am sensible, that I ought to regard that honour as offered, not to my own personal merits, but to the profession to which I belong; and that the council of the Glasgow Architectural Society, in requesting a Civil Engineer to address their meeting, must have desired to mark their sense of the intimate connection which exists between Engineering and Architecture,—two arts which have this in common—that each of them uses the mechanical properties of matter for the purposes of man; and which differ in this, that engineering is the more nearly allied to mechanical and physical science, while architecture is one of the fine arts. The engineer and the architect are alike constructors and mechanicians; but

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the engineer is most of the mathematician and man of science, —the architect most of the artist and poet.

I believe that I shall best fulfil the object which the council had in requesting me to speak, by endeavouring to point out and making some remarks on, those things which architecture and engineering have in common.

In former times, before the division of labour had been carried to the extent which it has since reached, the professions of architect and engineer, and of military as well as civil engineer, were almost always combined in the same man. As an example of ancient date we may take the case of Apollodorus, the architect and engineer of the good Emperor Trajan, who flourished about the end of the first century of the Christian era. As an architect Apollodorus designed many splendid edifices, of which some remains still exist, such as Trajan's pillar, the triumphal arches of Benevento and Ancona, and other buildings. As a civil engineer he planned and executed, amongst other works, the famous harbour of Ancona, and a great bridge across the Danube. That he was also a military engineer is proved by his treatise, still extant, upon engines of war. The most illustrious example of the same kind in more modern ages, was Michael Angelo Buonarotti, who together with his genius as an architect, sculptor, painter, and poet, possessed consummate skill as an engineer both civil and military, and in the latter capacity was of eminent service in the defence of Florence.

But in later times the subdivision of professions has drawn a line between architects and engineers properly speaking; and when an engineer, as on the present occasion, has to make remarks on architecture, he cannot lay claim to understand professionally more than the physical and mechanical part of the subject; so far as architecture is one of the poetical or fine arts, his knowledge of it can only be that of one of the general public.

So far as engineering and architecture consist in applying the science of mechanics to the art of construction, the knowledge required by an architect and that required by an engineer are almost identical. Each of them should understand all those general principles, and all those special properties of materials, upon which depend the three great requisites of an efficient and durable structure, stability, strength, and economy,—stability that the parts of which the structure is composed may retain their proper positions; strength, that each separate part may be in no danger of breaking under the forces applied to it; and economy, that neither materials nor work may be expended without contributing to the object of the structure. Stability of position depends on the figures and arrangement of the parts of which the structure consists, and the distribution of the load which they have to bear, whether from their own weight or from external pressures; and the principles by which it is regulated form a branch of the science of statics. The civil engineer must understand them, that he may know how to design a wall that shall sustain the pressure of a bank of earth, or a reservoir of water, or a chimney that shall safely bear the force of a storm; how to determine the figure of a tunnel that shall keep its shape at a great depth under ground; the form and properties of the arches and piers of a viaduct of stone or brick; the dimensions and arrangement of the beams of a timber viaduct, or of the bars and plates of one made of iron.

The architect has to apply the principles of stability almost exactly to the same extent and in the same way, to buildings in masonry, and framework of timber and metals; and in fact, the different styles of architecture may to a certain extent be distinguished and classed according to the kind and the greater or less complexity of the principles which regulate the stability of the structure. The simplest kind of stability is that of a single mass resting on a base, this is exemplified by pyramids, obelisks, and solitary pillars. Next in point of simplicity is the stability of a load resting on a lintel, whose two ends are supported by pillars, each of sufficient dimensions to be stable in itself. This we find exemplified in Egyptian and Greek architecture, and in those examples of Roman architecture from which the arch and dome are absent.

The next degree of complexity consists in supporting the load on each pier of which the structure consists by a pair of pressures inclined to each other; that is by introducing the arch and dome; and this we see in later examples of Roman and Italian architecture, and in various styles of the earlier middle ages, such as the Byzantine, the Lombard, and the Anglo-Norman. The perfecting and extending the application of the arch, so as to sustain the entire load of the higher parts of the structure by means of the thrust exerted through ribs, suitably formed and arranged, characterises Gothic architecture. The balancing of overhanging leads is seen to a certain extent in the beetling bartizans and turrets, which form the most picturesque feature of the Scottish Baronial style. The balancing of bulky arches upon comparatively slender pillars, whose lateral stability depends very much on their connection with the mass above them, is characteristic of Saracenic architecture. The styles of framework in roofs, and in buildings of wood and iron, might be classed in a similar manner, according to the way in which the principles of statics regulate the stability of the structure.

Another mechanical characteristic of styles in architecture is the way in which the strength of the materials is exerted. In the obelisk, pyramid, and simple tower or column, resistance to crushing is also brought into play; and the same is the case with the most elaborate combinations of ribs, groined arches, and tracery in Gothic architecture. In the styles which employ architraves supported by pillars, the transverse strength of lintels or beams is also employed. The support of overhanging loads requires the transverse strength of corbels and cantilevers, and in some cases the tenacity of cement and cramps. Timber and iron framework bring every form of strength into requisition.

A subordinate distinction of styles, founded also on mechanical principles, depends on the hardness and durability of the material of the building. For example, a certain plainness of style, which if executed in granite constitutes majestic simplicity, appears poor and bare in sandstone, and paltry in brick.

All these mechanical characteristics of styles in architecture, whether founded on the principles of stability, or those of strength, or on the special nature of the material, are as readily understood by the engineer as by the architect. They are connected with a certain sort of beauty—the beauty of stability and strength—which almost all persons can appreciate more or less, but of which the appreciation is much enhanced by a knowledge of the principles on which stability and strength depend. It is acknowledged by all that many works of engineering possess this kind of beauty. Suspension bridges, lattice-work and tubular viaducts, furnish many striking examples of it. It is a species of that class of beauty which arises from the fitness of a thing for a definite end. A swift and steady ship has beauty of this class; so has a well made steam-engine; so has a good rifle; and it is found in perfection in natural objects, especially living creatures.

Another source of beauty in architecture is what may be called geometrical beauty,—the beauty of order and symmetry: that which is possessed by a crystal, by the radiating petals of a flower, by the arrangement of any set of objects according to a definite and intelligible plan. This the engineer as well as the architect can produce.

There are some writers who would reduce all beauty to the two kinds which I have mentioned,—beauty of fitness, and beauty of order. But although I have hitherto dwelt on them alone, because they are common to works of architecture and works of engineering, I utterly oppose the opinion that they constitute all beauty. I feel that beyond them and independent of them there is beauty in itself, perceived by a peculiar faculty which all men have more or less, and whose existence in a pre-eminent degree and careful cultivation fits certain men for the pursuit of the fine arts; of poetry, music, painting, sculpture, and of architecture, considered as a means of expressing and exciting sublime and beautiful thoughts.

But although an engineer may be able along with others to appreciate and enjoy this kind of beauty in the works of architects, it is beyond his professional province. It is fitting therefore that I should leave its discussion to those who are better qualified than I am to do it justice; and should conclude by expressing my wishes that the architects of Glasgow may long be prosperous and famous, as they deserve, and may continue, as they have hitherto done, to adorn this city and the neighbouring country with works distinguished by beauty of fitness, beauty of order, and poetic beauty."

Enlargement of Paris.—The extension of the octroi walls to the lines of fortification has absorbed the greater portions of St. Denis and Sceaux. The area of the city is thereby increased from 8117 acres to 17,498 acres, or nearly 27½ square miles; and the population is raised from 1,174,346 to 1,525,942 inhabitants.

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DECISIONS ON THE METROPOLITAN BUILDINGS ACT IN THE SUPERIOR COURTS.

By Frederick W. Laxton, F.S.A., Barrister-at-Law.

The Queen *v.* Badger.—*Queen's Bench, Feb.* 9, 1856.

7 & 8 Vict. c. 84—Surveyor's fees—Receipt of fees improperly—Liability of surveyor—Jurisdiction of quarter sessions—Certiorario.

A complaint was made to justices at quarter sessions against C. B., a district surveyor under the Metropolitan Buildings Act 1844, which makes it an offence, by section 79, "if any surveyor demand or wilfully receive any higher fee than he shall be entitled to under this act, or if in his capacity of surveyor he receive a fee for any act or omission in respect of which he is not entitled to any remuneration."

The complaint alleged that three dwelling-houses of the fourth rate were covered in by the 29th November, and that three privies attached and belonging one to each of the said houses were carried up at the same time with the houses, and covered in by the 2nd of December, within 21 days after the said houses had been covered in; that in December C. B. delivered to complainant an account claiming a fee of £2 2s. in respect of each of the said houses, which was paid in January: that in February C. B. delivered another account to complainant, claiming a fee of 10s. in respect of each of the privies, and demanded payment of the same, and did in his capacity of surveyor wilfully receive the same from the complainant, not being entitled thereto under the act. Upon hearing this complaint the quarter sessions made an order under section 79 of the said act, stating the complaint to be well founded, and discharging C. B. from his office of surveyor forthwith. The complaint and order had been removed by certiorario, upon affidavits tending to show that C. B. had claimed and received the fees in respect of the privies, on the assumption of fact that they had not been carried up and covered in within twenty-one days of the covering in of the dwelling-houses, and that this fact was the question raised before the sessions. The certiorario was taken away by section 104 of the act.

Held (Lord Campbell, C. J., differing), that the sessions under section 79 of the 7 & 8 Vict. c. 84 had no jurisdiction to make the order, and that it therefore must be quashed.

In this case a writ of certiorari had issued for the removal into the Court of Queen's Bench of the following order and complaint: That at the general quarter sessions of the peace of our lady the Queen, holden at Maidstone in and for the county of Kent, on, &c., before, &c., the following order was made upon hearing a complaint of David Willoughby, of Forest-hill, in the parish of Lewisham in the county of Kent, grocer, in writing under his hand, against Charles Robert Badger, district surveyor of the said parish of Lewisham, appointed under and by virtue of the provisions of an act of parliament passed in the eighth year of the reign of her present Majesty, intituled, "An Act for regulating the construction and the use of buildings in the metropolis and the neighbourhood," setting forth the nature and particulars of the offence charged by the said complaint, and alleging that the said C. R. Badger in his capacity of surveyor as aforesaid, had demanded and wilfully received a fee to which he was not entitled under the said act, and contrary to the provisions of the said act: and upon hearing counsel on behalf of the said C. R. Badger, and also upon hearing the said C. R. Badger, and the evidence respectively produced by and for each of them the said David Willoughby and C. R. Badger, it appeared unto this court that such complaint is well founded, and this court doth discharge the said C. R. Badger forthwith from his said office. The complaint of D. Willoughby alleged "that C. R. Badger was, under the provisions of the said act of parliament of the 7 and 8 Vict. c. 84, intituled 'An Act for regulating the construction and use of buildings in the metropolis and in its neighbourhood,' on or about the 10th of December 1844, appointed district surveyor of the parish of Lewisham, in the western division of the said county of Kent, and that he the said C. R. Badger hath from thence hitherto and still holds the said office of and acts as district surveyor for the said parish. That your complainant the said D. Willoughby, did in the year 1853 erect and build three dwelling-houses of the fourth rate within the meaning of the said act, adjoining each other, at Perry-vale, in the said parish of Lewisham. That the said dwelling-houses were carried up and covered in by the 29th of November 1853. That three privies attached to the back of and belonging to the said dwelling-houses, being one privy to each house, were each and all of them built and carried up at the same time with the said dwelling-houses, and were covered in by the 2nd of December 1853, and within twenty-one days after the said dwelling-houses had been covered in within the meaning of the above-mentioned act. That in the month of December 1853 the said C. R. Badger, as such surveyor aforesaid, delivered to this complainant an account claiming a fee of £2 2s. in respect of each of the said dwelling-houses, amounting altogether to the sum of £6 6s., as being due to him as such surveyor, that such last-mentioned sum was duly paid by this complainant to the said C. R. Badger on or about the 12th of January 1854. That subsequently, in the month of February 1854, the said C. R. Badger, as such surveyor aforesaid, delivered another account to this complainant claiming a fee of 10s. as due to him as such surveyor in respect of each of the said privies, making together £1 10s., and did demand of this complainant payment of the said last-mentioned sum; and did on the 14th of July 1854, in his capacity of surveyor aforesaid, wilfully receive the same from this complainant, he the said C. R. Badger not being entitled thereto under the said act; and so the said D. Willoughby complains to you the said justices that the said C. R. Badger, in his capacity of surveyor as aforesaid, did on the day and year aforesaid, in manner and form aforesaid, unlawfully demand and receive a fee to which he was entitled under the said act, contrary to the provisions of the said act. Dated, &c."

The affidavit in support of the rule for the certiorario in effect stated that David Willoughby did in 1853 erect and build three dwelling-houses of the fourth rate within the meaning of the 7 and 8 Vict. c. 84, adjoining each other: that two of the said dwelling-houses (the northernmost) were carried up and covered in within the meaning of the said act by the 22nd of November in the said year 1853, and that the other was carried up and covered in within the meaning of the said act by the 2nd of December 1853 at the latest: that he, this defendant, duly surveyed the same: that three fees of £2 2s. each, amounting together to £6 6s., were under the said act due to the applicant, as district surveyor of the district of Lewisham, for the supervision of the building of the said three houses, and were paid about the 12th of Jan. 1854: that David Willoughby built to each of the said three houses an attached building called a privy, which said attached building had no internal communication with the house to which it belonged: that the said privies were attached buildings distinctly rated under the said act as belonging to the fourth rate: that the privy at the back of the northernmost of the said three houses was partly covered up with a slate cistern about the time that the said three houses were carried up and covered in: that such cistern did not cover the whole of the top of the said privy, but that a portion of the area inclosed by the walls of the said privy was left wholly uncovered and open to the air: that this open space was 12 inches in width at the broadest, and that considering the size of the privy, the leaving this open space uncovered was leaving uncovered a material portion of the roof or top of the said privy contrary to the regulations of the said act: that this uncovered space was not covered in within twenty-one days after the said house to which the said privy belonged had been carried up and covered in, but was covered in after the expiration of such period: that the privy attached to the southernmost of the said three houses, and the privy attached to the middle house of the said three houses, were attached to each other and separated by a party-wall: that there was no internal communication between the said two last-mentioned privies: that the said party-wall was not built and carried up of the thickness required by the said act of parliament for a party-wall between two such buildings at the time the said houses were built, nor within twenty-one days after such houses had been covered in within the meaning of the said act: that on or about the 9th of December 1853, the applicant, as district surveyor, surveyed the said attached privies, and found that the privy to the said northern house had not been covered in, and that the party-wall between the privies belonging to the said middle and southern houses had not been carried up according to the act, the said wall being only 4 inches thick instead of at least 8½ inches thick as required by the said act, and thereupon complained to the bricklayer employed about the said buildings, and then required him to amend the said wall: that on the 7th and also on the 17th of February 1854, he again surveyed the said three privies, and found on each of those occasions that the privies had not been any of them completed: that the said party-wall had not been carried up of the proper thickness, nor had the privy of the said northernmost house been covered in: that he again surveyed the said privies on the 25th of February 1854, and found that in the interval between the 17th and 25th of February 1854 the said party-wall had been carried up of the requisite thickness, and that the said open part of the top of the privy to the said northernmost house had been covered in with a covering of tiles and cement, and that all the said privies were then duly completed: that he verily and truly believed that he was lawfully entitled to demand and receive from the said D. W. a fee of 15s. for the supervision of the building of each of the said privies, and for his time, trouble, and expenses in causing the rules, regulations, and directions of the said act to be observed with respect to the same: that under such belief he did after the expiration of one month after the roof of the said attached privies had been covered in and the walls thereof built to the full heights, and the principal timbers and floors thereof had been fixed in their places, and more than one month after the completion of the said premises, deliver to the said D. W. an account of the fees incurred, stating the amount of such account and the work done: that in the month of July 1854 he received from him the said three several sums of 10s. each as and for the supervision respectively of the building of three attached buildings, being privies attached to houses, and not being built at the same time and not carried up and covered in within twenty-one days after such houses respectively had been covered in within the meaning of the said act of parliament; and that he tendered and gave to the said D. W. a receipt for the said fees, stating the amount and work done.

The affidavit then set out the evidence at the hearing before the justices, showing that the fees were claimed on the ground that the party-wall had not been carried up nor the privy covered in until after the time allowed by the act, and the applicant therefore believed himself entitled to the fees.

A rule was afterwards obtained calling upon the complainant and the justices of Kent to show cause why the order should not be quashed. The affidavit used in answer to the rule stated the evidence of the complainant before the justices, and that the only question then tried was, whether the surveyor was entitled to any fee in respect of the privies beyond the sum of £6 6s. paid for the supervision of the dwelling-houses, it being contended that, independently of the question whether the privies were built and covered in within twenty-one days, they were substantially part and parcel of the dwelling-houses, and therefore necessarily included in the supervision of the dwelling-houses.

The substantial question argued was whether (the certiorario being taken away by section 104 of the statute 7 and 8 Vict. c. 84) the order

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in question was within the jurisdiction given by section 79 of the same statute.

The judges differing in opinion, delivered their judgment seriatim.

Held by Erle, J., that it appeared from the complaint—or, if that were doubtful in its meaning, from the affidavits, which might then be looked at—that the fees were claimed and received on the assumption of fact that the privies were not carried up and covered in within twenty-one days, and that the 79th section did not extend to a fee so claimed and received, though the assumption were found by the sessions to be mistaken.

By Coleridge, J., that under section 79 the jurisdiction of the sessions was confined to the case of the receiving a fee for an act or the omission to do an act, for which even if done or omitted to be done as alleged no fee is authorised by the act; and that the complaint, after reference to the affidavits which were admissible to disprove jurisdiction, showed that the question tried and decided at the sessions had reference to facts which if the surveyor were correct entitled him to the fee claimed.

By Lord Campbell, C. J., that the affidavits could not be looked at. That the whole proceeding upon the face of it appeared to be regular; and that as the complaint, which was found to be true, charged that the surveyor wilfully demanded and received a fee for an act in respect of which he was not entitled to receive any remuneration, the sessions appeared to have jurisdiction to make the order; and that the certiorario therefore ought to be quashed.

THE QUEEN *v.* JAY.—*Queen's Bench, Nov.* 14, 1857.

Buildings erected by the Commissioners of Lieutenancy of the City of London under statute 1 G. 4, c. 100, s. 39, and statute 17 & 18 Vict., c. 105, s. 2, for the custody of the arms and stores of the militia, are within the exemption in section 6 of the Metropolitan Buildings Act 1855, as employed for Her Majesty's use or service; and it is not necessary to give notice to the district surveyor before commencing the building under section 38.

This was an appeal against a conviction by a police magistrate.

The building, which was under course of erection by the above-named John Jay, under a contract with Her Majesty's Commissioners of Lieutenancy for the city of London, was being built by the commissioners under the powers and directions of the statutes above-mentioned, and for the purposes of a militia depot and headquarters of the Royal London Militia, and for the depositing and safe custody therein of the arms, accoutrements, clothing, and stores of the Royal London Militia.

It was contended, that the building could not be said to be "employed for Her Majesty's use or service." It was not employed at all, not being completed, and when completed it would not be employed directly for the crown, but for the commissioners. The word "employed" cannot be taken in the literal sense: if it could, a house might be improperly built without the superintendence of the district surveyor, and then be left standing upon the commissioners hiring another building for their purpose.

Lord Campbell, C.J.—The building is employed for Her Majesty, for it is to be applied to the custody of the arms, &c. of her troops. For what other purpose can it be said to be employed? The object is that it may serve for the deposit of military stores and for securing the arms.

Coleridge, J.—The exemption applies to all buildings employed in Her Majesty's service. It is intended for Her Majesty's use. Buildings in the possession of the crown, such as the royal palaces, are exempted, and then to prevent doubt, larger words are added. If the building were used for the custody of the arms of regular troops there could be no doubt: and what difference can it make that the troops here are militia?

Wightman, J.—For what other use is the building? Common gaols are exempted also.

Conviction quashed.

(Reported in 8 Blackburn and Ellis's Reports, 469; 27 Law Journal, Queen's Bench, 139, and 4 Jurist, N.S. 407.)

Re C. R. BADGER.—*Queen's Bench, Jan.* 16, 1858.

A railway company incorporated by and acting under the provisions of a statute, constructed their railway by a viaduct formed of arches of brickwork, and used the viaduct and arches for the purposes of the railway. Afterwards a space was inclosed under an archway by building walls with gates at each end, and constructing two stories in the inclosed space. The space so inclosed was used by a lessee of the company as a stable, and not for the purposes of the railway. After the passing of the Metropolitan Buildings Act 1855, alterations were made in the inclosing walls. The district surveyor having claimed fees in respect of such alterations under s. 49; Held, that the fees were not claimable, and the structure not liable to the operation of Part 1 of the Act, but exempt under s. 6, as a building belonging to a railway company used for the purposes of such railway under the provisions of an act of parliament, since the archway itself was so used, and the addition did not of itself constitute a building, and that this was not the case of an alteration of or addition to an old building within the meaning of s. 9, that section applying only where the old building is itself within the operation of the act.

A police magistrate made an order on the company for fees to be paid to the district surveyor, the complainant; and a case was stated for the opinion of the court. The South-Eastern Railway Company, before the 1st January 1856, caused to be erected at each end of each of three of the railway arches a brick wall, with doors for ingress and egress, and other certain openings in the same. The said brick walls were built wholly upon land of the company, and wholly within the said arches respectively. Between the said brick walls and the piers and crown of the said three arches were thus inclosed three several spaces containing two stories respectively, which were permitted by the company to be occupied by a person who used and occupied them as stables for horses; but the said inclosed spaces were not nor was either of them used for the purposes of the railway, except in so far as the company received payment for the use and occupation. After the 1st January 1856, the company made certain alterations in the brick walls so erected at the ends of the three arches respectively. The district surveyor demanded certain fees in respect of the alterations.

Lord Campbell, C.J.—This case is by no means free from doubt and difficulty, but, upon the whole, I am of opinion that the conviction was wrong, and that it ought to be quashed. I should be inclined to think that these inclosed arches would be buildings within the meaning of the act, but then it seems to me, that there is an exemption of which the company may avail themselves, that is to say, that which applies to the buildings belonging to any railway company, and used for the purposes of such railway. Now, the arches and all but the mere walls are used for the purposes of the railway, they were erected for that purpose, and from that part the surveyor is excluded. Then what is the other part? why nothing but the exterior walls, which cannot be said to be houses, or by themselves to be buildings, within the statute. I think therefore that by the exemption in section 6, these stables are taken out of the operation of the statute. And at the same time, I would advise the owners of the property to avail themselves of the provisions of section 56, under which they may lay a plan before the board, and obtain its sanction for the erection of these places. The main part was erected for the purposes of the railway, and the remainder is not a "building."

Coleridge, J.—I am of the same opinion; but my mind has wavered a good deal in the course of the argument. The building consists of an ancient viaduct built by the railway and used by them. I hardly know what is contended. Is it that the whole, by reason of the addition which has been made, is within the fact? I cannot admit the arch is so, for that would lead to the inconvenient consequences which have been referred to in the argument. Then nothing remains but the walls which have been added closing in the ends of the arches; but these walls cannot be said to be buildings. It is said that a wooden end could not be put to the arch without making the whole subject to the act, but I am clearly of opinion that that could be done, as for the purpose of keeping a fire engine, or anything of that sort.

Wightman, J.—The only question is, whether these places come within the exemption clause, as buildings belonging to a railway company and used for the purposes of such railway? The arches were at first so used, but they have subsequently been occupied as stables by a tenant, and might be occupied for other purposes, as for dwelling-houses. I have had some doubt as to how much of section 9 applies to this case. That section enacts that "any alteration, addition, or other work made or done for any purpose except," &c., "in, to, or upon any old building, or upon any new building after the roof has been covered in, shall to the extent of such alteration, addition or work," be subject to the regulations of the act. I had some doubt whether the new work might not be within that section, but I think that such addition must be to some building already within the act. The main object for which the arches were erected was for the railway, and many of the provisions of the act are quite inconsistent with, and inapplicable to such places. I think therefore, though with some doubt, that the conviction was wrong.

Crompton, J.—I have come to the same conclusion as the rest of the court. Looking at the exemption clause and the rest of the act, I am unable to say that these are buildings within the provisions of the first part of the act. I could not say that the arches and the roof were so. It may be that the legislature gave credit to railway companies that they would take care to secure their buildings, and therefore took them out of the jurisdiction of the surveyor. I do not think that the arches and piers constitute buildings. Then is the wall so? I cannot think it is. Section 9 will not help Mr. Badger, for that mainly applies to additions which have been made to what was already a building within the meaning of the act. The principal part is not a building, and the fact that the rest may be called so will not make the whole liable to the supervision of the surveyor.

Conviction quashed, without costs.

(Reported, 27 Law Journal, Queen's Bench, 201; and 6 Ellis and Blackburn's Reports, 728.)

EVELYN, appellant, *v.* WHICHCORD, respondent.—*April* 24, 1858.

Metropolitan Buildings Act 1855, 18 and 19 Vict. c. 122, ss. 3, 51—Liability to surveyor's fees—"Owner."

E. the owner in fee of land, agreed to let it to S. on a building lease for eighty-one years, at a peppercorn rent for the first year, £6 the second, and £12 per annum for the remainder of the term. S. entered under the agreement, and commenced building houses in respect of which, during the first year of the tenancy, certain fees became payable to the district surveyor under section 51 of the Metropolitan Buildings Act 1855, (18 & 19 Vict. c. 122) from the builder, owner, or occupier of the buildings. Held that E. was not liable, for that he was not "owner" within the meaning of sections 3 and 51. This was a case stated by a police magistrate for the opinion of the court. On the part of the appellant it was contended that in the interpretation clause of the act the word owner applies to every person in receipt of the rents and profits either of the whole or of any part of the rents and profits of any land or tenement, other than as a tenant from year to year or for any less term, or as a tenant at will, and that even supposing the appellant did come within the

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meaning of the word "owner" he was not liable to the payment of the surveyor's fees, except in default of persons previously mentioned in the act, viz. the builder and the occupier, against whom proceedings for the recovery of the fees must first be taken.

Lord Campbell, C. J.—I am of opinion that the appellant was not liable to these fees, as not being "owner" within the definition of the act. He was certainly not the occupier, and therefore he can only be chargeable as "owner," that is as being in the receipt of the rents and profits. I think that he is not in the receipt of the rents and profits within the meaning of the act. At the time these fees became due the land was let at a peppercorn rent; the appellant therefore received no profits. We cannot hold him liable unless in every case where land is let on a building lease, the ultimate reversioner is to be held liable, and the surveyor entitled to come upon him for his fees. I think that this would be subjecting the landlord to a most oppressive and unnecessary liability, and one which I cannot think the legislature intended. In the present case there was no immediate rent and profit of which the appellant could be said to be in the receipt.

Erle, J.—Looking at the particular circumstances of the case, I concur with the rest of the court.

Crompton, J.—I am not satisfied that the appellant is brought within the definition of "owner" as used in this act of parliament. The interpretation clause of an act is very often the most difficult part to understand, but in the present case I am not satisfied that the appellant is in possession or receipt of the whole or any part of the rents and profits. The question is whether the appellant is the owner or occupier of the building: he is not in the occupation clearly, but it is said he is owner because he is in possession of the rent of a peppercorn. My notion is that the definition points to a person who either receives himself or by his tenant the whole or part of the rents and profits, and I do not think that a peppercorn reserved as rent can fairly be said to be part of the rents and profits. I think the lessee for eighty-one years or his assignee had them, or part of them; "any part" meaning part of the whole.

Judgment for the appellant. (Reported in 27 Law Journal, Queen's Bench, 211.)

WHEELER *v.* GRAY.—*Common Pleas, May* 24, 1858.

A landlord is justified under the 83rd section of the Metropolitan Buildings Act 1855, in entering premises in the occupation of his tenant from year to year, and pulling down and rebuilding the party-wall between it and other premises belonging to him, without giving the notice required by s. 85. Such tenant not being an owner within the interpretation clause s. 3, and it is no objection that he has neglected to give the notice to the district surveyor required by s. 88. Semble that the landlord would if necessary, under such circumstances, be a "person" entitled to notice of action under s. 108.

This was an action of trespass in breaking and entering certain premises in the occupation of the plaintiff in Gray's-place, King's-road. The facts which appeared in evidence were as follows:—The defendant was the owner of the house in Gray's-place, which was in the occupation of the plaintiff as tenant from year to year under him. The defendant was also owner of the adjoining house. The party-wall between the two houses being in a state of dilapidation, the defendant, without the permission of the tenant and without giving any notice to the district surveyor or to the tenant, entered the house in plaintiff's occupation and pulled down and rebuilt the wall. The jury found that the wall in question was so far defective or out of repair as to make it necessary or desirable to pull it down. Verdict for the plaintiff: leave to the defendant to move to enter a nonsuit or a verdict for him if the court should be of opinion that he was entitled to a notice of action or justified in what he did.

Cockburn, C.J., said that the case fell within section 108, and consequently that the defendant was entitled to a notice of action, and further, that the action should have been brought within the time prescribed by that section for the commencing of actions for anything done or intended to be done in pursuance of the act. Independently also of that section, the defendant was perfectly justified in what he did. The defendant was "owner" of the premises occupied by the plaintiff, and "building owner" with reference to the premises not occupied by the defendant. He therefore was entitled under section 83, when the party-wall became decayed, upon giving notice, if notice was necessary, to go upon the premises and do the repairs. The 85th section requires notice to be given to the owner of the adjoining premises, but here there was no adjoining owner other than the defendant himself.

Williams, Willes and Byles, Justices, concurred.—Rule absolute for a nonsuit.

(Reported in 4 Common Bench Reports, new series, p. 585; and 27 Law Journal, Common Pleas, 267.)

LABALMONDIERE, appellant, *v.* ADDISON, respondent.
Queen's Bench, Nov. 6, 1858.

18 & 19 Vict. c. 122, 11 & 12 Vict. c. 43, s. 11—Recovery of expenses—Limitation of time for complaint.

By s. 73 all expenses incurred by the commissioners in respect of any dangerous structure shall be paid by the owner; and by s. 103, all expenses to be recovered in a summary manner may be recovered as directed by the 11 & 12 Vict. c. 43, by s. 11 of which complaint must be laid within six months from the time when the matter of such complaint arose. The owner of a dangerous structure not having taken it down as required pursuant to the former act, the commissioners took it down; and the amount of the expenses incurred was demanded of the owner, and refused. A complaint was laid before a magistrate for the nonpayment of the expenses within six months of the demand and refusal, but beyond six months from the completion of the works. Held, that the matter of complaint was the nonpayment of the expenses, and that the time of limitation ran from the demand and not from the completion of the works, therefore that the complaint was in time.

(Reported, 28 Law Journal, Queen's Bench, 36; and 5 Jurist N. S. 431.)

DIAGONAL FRAMING FOR IRON SHIPS.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—Mr. Taylerson, whose project you elucidated in your November number, has clearly moved a step in the right direction, but he has only put the left foot foremost; before we can advance on the principle he proposes the right must be attended to as well as the left.

For the purpose of discussion, the breadth and length of a ship may be looked upon as an oblong platform. Could it be considered under the circumstances of a floor, that is joists or beams *supported* at the ends and planked over, there could be no mechanical objection to the diagonal placing of the beams or joists. But our oblong platform must be considered under totally different circumstances; viz., the ends of the joists or beams *not* being supported. It has often occurred that portions of floors with the joists attached have been taken up and used as temporary platforms, but when deprived of the bearings on the tassels and walls, they had no strength but in the direction of those joists; across, or as a sailor would say athwart, the joists or beams, they were but as paper.

The roughest woodman on the water-side, were he desired to construct a raft of heavy spars and planking over, would not put all the spars one way; to save his labour and some stuff he probably would place the best spars lengthways first, the lighter ones across on them, and then the planks from end to end; but a better platform far would be constructed of the same weight of stuff, by placing the spars diagonally from both sides, as shown in fig. 1, the planking to go lengthways as before.

FIG. 1.

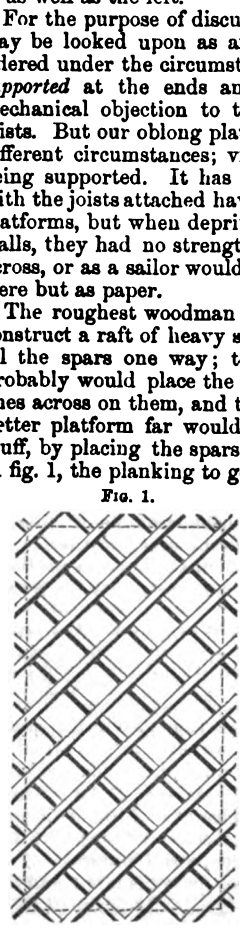
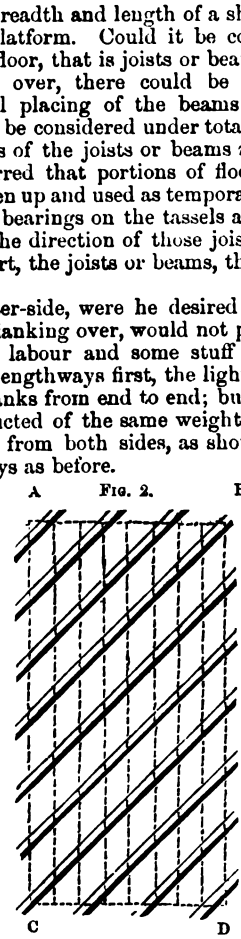


FIG. 2.



Suppose for a moment that only one layer of beams should be provided and placed diagonally, as in fig. 2 (and as proposed), and then the raft or platform to rest upon a ridge of rock or sand extending in the direction from C to B: it is obvious that A and D would sink until support was found, or the raft break across, as was the case with the Royal Charter, and many other vessels.

I fear that until we can cross Mr. Taylerson's diagonal beams by others, nothing will be gained save cost and trouble, unless we gain a mischief; for it is perfectly obvious that—placing reliance on the beams alone—a vessel so constructed, that is with single diagonals as in fig. 2, would be infinitely weaker athwart those beams than a vessel of ordinary construction. In fact, until plated, depending for her strength in one direction on the keel and keelsons only, she would not be a frame at all!

The longitudinal and upright frames or trusses, first introduced (I think) in the Himalaya, appear to be as yet the surest and the simplest mode of strengthening large craft longitudinally.

PRACTICAL MECHANIC.

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ON THE GREAT EASTERN.*

By William Hawes.

I propose to treat the ship as a great mechanical and engineering work—fraught with great commercial and political results, the accomplishment of which may be retarded by bad management, but which will certainly be ultimately realised, however gloomy for a time the prospects may appear to the company engaged in the enterprise. My object is to endeavour to restore that confidence in the ship which, but a few weeks back, was so perfect, and to separate from the great principles involved in the undertaking all petty jealousies and misrepresentations.

It is only within a very recent period that ocean steam navigation has been accomplished, and within a still more recent period that iron has been used for the hulls of ships, and that the first great step in this direction was the construction of the Great Britain an iron ship of 3500 tons burthen, by Mr. Brunel, in 1844. Until the causes of the disturbance of the regular action of the compass in iron ships were understood and overcome by the researches of science and practical experience, there was very great, but perhaps proper unwillingness on the part of shipbuilders to adopt a new material for shipbuilding, or to appreciate, as they now do, the special advantages due to the use of iron in the construction of ships of large tonnage.

The greater strength, but less weight, of properly constructed iron ships—their stiffness, or "stand-upativeness," as I once heard it called—their freedom from working, and lessened liability to leakage—their superior safety in case of accident by lightning or fire, as shown by the Sarah Sands, and—when properly divided into compartments, by honestly constructed bulkheads—their comparative freedom from several classes of accidents to which wooden ships are liable, added to the superior facilities afforded for fixing their machinery, are some of the advantages of iron ships, but which, plain and universally admitted as they now are, were long in receiving the assent of builders and navigators. So again with the screw and paddle, as the means of propulsion. At first the paddle was universally adopted. The screw obtained support very slowly, and when its merits were admitted it was for a long time used only as an auxiliary power to merchantmen and ships of war.

Experience has, however, gradually shown the peculiar advantages belonging to both modes of propulsion, and one of the most successful novelties in this great ship is the union of the powers of the screw and paddle and sail, by which she is more perfectly under control than any ship driven by one power only, or by the combination of two of them.

I must call your attention—first, to the early history of the design of this ship. Secondly, to the peculiarities of its construction—its form—its power—its longitudinal and transverse bulkheads—its masts, rigging, and miscellaneous machinery. Thirdly, to the consideration of its value as a portion of our mercantile marine; and lastly, to the vast results we may expect to follow the success of this masterpiece of shipbuilding, mechanical skill, and engineering science.

When Mr. Brunel first adopted the idea of building so large a ship I cannot say, but recollecting many conversations with him upon large ocean steamers, and looking to the progress of his public works, it is evident it had long occupied his mind, and that the exact mode of carrying it out was gradually matured as he built the Great Western and Great Britain, and other ocean steamers. In 1835 he designed the Great Western—in 1842 he designed the Great Britain—and in 1851 he designed the Great Eastern.

In the Great Western and Great Britain his leading idea was to improve, by shortening and rendering more certain, the communication between America and England, the average passages by the best clipper sailing ships, at that time, being 35 or 40 days outward, and 20 or 25 days homeward. The Great Western made her first outward voyage, with 7 passengers, in 15 days, burning but 400 tons of coal; returning with 87, the largest number of cabin passengers which had crossed the Atlantic in one bottom. She was a wooden paddle steamer of 1400 tons burthen and 400 horse-power, 236 feet long and 35·6 broad; 50 feet longer than any steamer then afloat, and by far the largest then built.

The Great Britain started from Liverpool, on her first voyage, Sept. 22, 1846, with 185 passengers; but was wrecked when starting on her fourth voyage, on the rocky coast of Dunlrum Bay, where she remained, subject to the violence of the winter gales, till the spring of 1847, when she was got off, uninjured as regarded the hull, the lines of which were unaltered, and she is now running regularly to Australia. This was an iron ship, of 3500 tons burthen, 322 feet long, 57 feet broad, and with engines of 800 horse-power. In the material of which she was built, her size and power, and in her being driven by a screw, this ship was an enormous advance on the Great Western, and her success led, no doubt, to the Great Eastern, in the construction of which the aim of Mr. Brunel was of still greater import, inasmuch as the magnitude of the interests involved in our Eastern possessions are superior to those in the Western world.

During the interval which elapsed between the building of the Great Britain and the Great Eastern, the political and commercial relations of this country with India advanced with giant strides, and the necessities of the imperial government, the demands of commerce, and the wants of a large passenger traffic, required that some safe and rapid means of communication should be found, entirely independent of other countries, and less troublesome to passengers than the present overland route; and I cannot help here expressing my regret that so much time has been lost in trying the great experiment for which this ship was built,—any delay in realising which is, I think, a national loss.

I have stated that the idea of a large ship, able to carry coals sufficient for a long voyage, and to attain a comparatively high speed, had assumed a tangible form in 1850-51. Early in 1852 the plans were submitted by Mr. Brunel to the directors of the then Eastern Steam Navigation Company, when that company was reconstituted, a new direction formed, and in July a report was published, in which it was proposed to accomplish the voyage to India *vid* the Cape, in from 30 to 34 days, without stopping to coal, and with space enough to carry sufficient first-class passengers and freight, at moderate rates, to secure an ample remuneration to the shareholders.

In this prospectus, Mr. Brunel's acknowledged reputation as a marine engineer was fully recognised, and in a short time after this meeting the design of the ship was completed, and the drawings, embodying the most approved forms, in combination with every mechanical appliance which could give strength to this vast structure and by their simplicity give confidence even to those least advanced in mechanical knowledge, were submitted to the criticism and approval of the world, and these plans were not materially altered at any subsequent period.

So soon as these plans were published, Mr. Brunel became the nucleus round which concentrated every new idea, whether of the practical or theoretical shipbuilder or of the enthusiastic schemer, in the old or in the new world; and no doubt, now that a great success has been achieved, many of these correspondents, finding that plans somewhat similar to those they suggested have been adopted by Mr. Brunel, believe themselves to have been the inventors, and will hereafter claim merit accordingly. This is the case in all great works, but the public and posterity always decide rightly in the long run as to whom merit is due, well knowing that one of the best evidences of genius and of the possession of the highest qualities of the mind, is the power of collecting, digesting, and sifting all existing information, and then practically applying what may be good for the purpose required, filling up by its own genius what is wanting to make a perfect whole.

It is difficult to estimate the injury to the company caused by the loss of the superintendence of the master-mind of Mr. Brunel, in the completion of this great work. No one appears to have sufficient authority to decide what is to be done; few, I fear, of those who are now connected with the administration of the company's affairs appreciate the vastness of the original design, and fewer still are able to carry it out in its integrity. Judging from the criticisms we have all read upon the ship of late, we might fancy that neither of the experienced engineers of the paddle and screw engines knew anything of their business: for one critic says the chimneys are too small; another, the boilers are insufficient; another, the diameter of the paddles is too great; another, the air-pump rods are too weak, and the engines themselves are in the wrong position; another finds fault with the donkey engines; and so on throughout the ship: all of which criticisms seem rather to originate in a desire to spend the money of the company, or to obtain a false reputation by appearing to remedy evils which do not exist, than to complete in the shortest time the work that is

* Abstract of a paper read before the Society of Arts.

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unfinished, and to remedy, in the most economical manner, defects in her machinery and apparatus which her trials have rendered apparent.

Throughout the year 1852, Mr. Brunel's attention was very much directed to ocean steam navigation, and he was brought constantly in contact with the leading shipbuilders and engineers. The first question he had to decide, and upon it many others depended, was the place of building. Was it more to the interest of the company that so large an iron structure should be built in London than in the North, where it was alleged both iron and labour, skilled and unskilled, the two great elements of cost, were the cheapest? His decision on this point was much canvassed, but Mr. Brunel attached more importance to the facility which building in London would afford him for constant personal superintendence, and by which alone he could insure that attention which he thought indispensable to the most minute details of its workmanship, than to any apparent economy in the cost of the transmission of the materials from the North to London. This being decided, Mr. Scott Russell was selected, as the most advanced iron shipbuilder, to construct the ship and make the paddle engines; the screw engines being given to the old and eminent firm of Boulton and Watt.

Of the engines, as differences exist between the directors and the contractors, it is not desirable for me to speak, but I think it right to say, that so far as they went their working was beautiful.

So soon as Mr. Russell obtained the contract to build the ship, and even at an earlier period, when, from being in communication with Mr. Brunel respecting contracts for other ocean steamers, he became aware of the plans for this great ship, he gave Mr. Brunel all the information he possessed as to the best form of entrance calculated to offer the least resistance in passing through the water; and the time he had devoted to the study of the wave-line or hollow bow for ships gave great weight to his opinion: but this was solely as to the exact curve to be adopted, and not upon the principle whether a hollow or a bluff bow was best for such, or indeed for any, steam ship. All the leading and most important questions, as to size, form, and construction, were settled early in 1852, if not in 1851. The cellular hull and main-deck, the position of the longitudinal and transverse bulkheads, were then finally determined, and so arranged as to place the accommodation for the first-class passengers in the centre of the ship—in the place of least motion, instead of quite aft, or in that of the maximum motion, as is now universally adopted; the number of masts and their material, the size, power, and situation of the engines, and the position and size of the coal bunkers were also arranged, leaving nothing for future consideration but the exact appropriation of the large spaces between the bulkheads and above the main-deck to first, second, and third class passengers, the accommodation of the crew, and for general cargo.

To carry out these leading ideas, and to insure the speed required, Mr. Brunel adopted the following dimensions and arrangements as most likely to accomplish the results he desired, viz.—

The length of keel, 680 feet; the length of upper deck, 692 feet; breadth of beam, 83 feet; depth 58 feet; engines of 2600 horse nominal power; a midship section of 1600 square feet, with a capacity of carrying 12,000 tons of coals, a large number of passengers, and 10,000 tons of cargo.

The centre of the ship above the main-deck he appropriated to passengers; the space below the water-line to the boilers, engines, and coal bunkers. This space is 350 feet in length, and is divided into three compartments by two substantial bulkheads running fore and aft the entire depth of the ship. The centre compartment, 36 feet in width, is exclusively occupied by the engines and boilers. The outer compartments are filled with coals. The boiler rooms are arched over with an iron roof, to prevent the radiation of heat from them into the ship, and also to prevent the escape of smoke and other unpleasant smells into the cabins above them. This complete isolation of the boiler department from the rest of the ship is quite novel, and is a great security to the passengers against injury from any accident which may happen to them. The remaining 332 feet of the ship is about equally divided fore and aft, and is appropriated to cargo and stores.

So much for the basement of the ship. The space immediately above the 350 feet we have thus described, is divided into two parts by the paddle engine room, which occupies, including the engineers' and the stokers' berths, a space of 40 feet in length and the entire breadth of the ship, thus separating the first from the second and third class passengers; the first being in the forward compartment, and therefore subject to less inconvenience from smoke or dust, as also from any vibratory motion arising from the working of the screw. With this exception there is no real difference, so far as the ship is concerned, in the accommodation of the third, second, and first class passengers. Of course, the fittings of the cabins, the number of berths in them, and the dietary, would be different in the first, second, and third classes.

At first sight it may be said that this ship is but so much longer and so much broader and so much deeper than such and such a ship, built by this firm at one place and that firm at another; that all these efforts of marine architecture were outdone in olden time, if we consider size only, by Noah's Ark, which is said to have been 680 feet long; and by Ptolemy Philopater, a Græco-Egyptian, who is said to have built a ship 420 feet long, carrying 400 sailors, 400 rowers, and 3000 fighting men

How then has this confidence in her strength been gained? Not because of her size, for so many large wooden and iron ships have been lamentable failures, from the great White Ship—built by Henry I., which was lost, with her builder, the king's son, and all the crew, on the first voyage—to the Great Merchant, built by order of James I. of Scotland, of 1000 tons, lost on her trial voyage, and the Henri Grace de Dieu, of 1500 tons burthen, built by Henry VIII. in 1520, which being found quite unmanageable was laid up after one trial, and went to decay.

From this time to 1637, above 100 years, we only hear of one large ship, the Royal Sovereign, the first three-decker built, of 1861 tons burthen, and 128 feet long. We again await another century, till 1756, when the Royal George, of 2046 tons burthen was built. The next 50 years produced the Hibernia, of 2500 tons, and 201 feet long, in 1804. This was the first 110-gun ship launched. From this time the size and number of our large ships of war has steadily increased, but at a cost for labour and material to insure safety quite unapproachable by private owners, whose experience in wooden ships, as exhibited in the fate of the President, which has never been heard of, and of the British Queen her sister ship, which like the Henri Grace de Dieu is laid up to rot, and in iron ships by that of the Birkenhead and others, led them until recently to avoid rather than to build large ships.

The first and most important addition of strength is gained by the cellular construction of the hull and deck. It is a double ship to 3 feet above the water-line, held together by ribs of immense strength, at intervals of 6 feet each, which are united to transverse plates, dividing the entire surface of the ship into spaces of 6 feet square. The next element of strength we find in the two longitudinal bulkheads, the entire depth of the ship, firmly fastened to the transverse bulkheads, and thus forming two bars of iron 60 feet high, 350 feet long, and ½-inch thick. The force required to tear these asunder, as well as to rend the double cellular hull, is more easily imagined than described, and is certainly very far beyond any strain which, under known conditions of ocean navigation, can possibly arise. The strength obtained by this arrangement was tested during the launch, when unexpectedly, and for the long period of two months, the ship was supported on two cradles, each 120 feet in length leaving above 150 feet at each end, and about 100 feet in the centre of the ship without support, and the most careful observation could not detect the slightest change of form.

So much for its length. Next, as to its breadth. The cellular construction of the hull is also a source of strength against a transverse strain, but this is more particularly provided for by the cellular upper-deck, and by the twelve transverse bulkheads, each forming a plate or bar of iron 58 feet deep, 80 feet long, and ½-inch thick. These transverse bulkheads, stiffened by their fastenings to those running longitudinally, and the cellular construction of the hull and deck of the ship, give to the whole a uniform strength which has never before been attained.

The strength of the general structure, and its power to resist a transverse strain, was tested in an unexpected manner by the accident which happened during her voyage to Portland. Here was the explosion of a boiler at very high pressure, 30 feet long and 6 feet in diameter, the force of which lifted the entire chimney weighing 8 to 10 tons, many feet high, carrying away and overcoming the resistance of all its fastenings, without doing the least injury to the frame of the ship; and it is equally remarkable that the heavy funnel being lifted from the bottom of the ship to several feet above the deck, should fall upon it, and cause but the

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most trifling damage, so that not only was the general structure or hull tested by the resistance it offered to the lateral force of the explosion, but the strength of the deck was tried in a manner never calculated upon, and both bore these tests to the admiration of everyone who has since examined the ship, but especially of those on board, none of whom could, without such experience, have believed it to be possible that a ship exposed to such an explosion could afterwards have carried them, without a moment's delay, safely to their journey's end.

These, then, are the peculiarities of construction which have given to this large ship such strength and safety, as not only to forbid the idea of increased danger from its great size, but to convey to the mind a sense of security greater than can be afforded by any ordinary mode of shipbuilding, and form the practical engineering improvements over any other large ship yet built.

Next consider the motive power. Here, taking advantage of experience—appreciating the advantages of the paddle which are great, and those of the screw which are equally so, both having drawbacks under special circumstances, and each also possessing advantages calculated to overcome the deficiencies of the other—Mr. Brunel determined to apply both, giving the preponderating power to the screw; and singular it was that the advantages of this combination should have been exhibited while the ship was at Holyhead, during the late storm, when the screw, fouled by floating timber, was freed by the gentle action of the paddle, and injury to the paddle floats prevented by stopping the paddle engines and propelling the ship by the screw, thus alternately using first one and then the other, the safety of both being secured by the alternate action and rest of each.

It is perhaps fortunate that in so short a time the ship should have undergone three unexpected tests of her efficiency—of her longitudinal strength in the launch, of her lateral strength by the explosion, and of the utility and safety arising from the double motive power at Holyhead, in each case the success being complete.

The steadiness of the ship at sea may be to some extent attributed to this double motive power, each shortening the interval which would elapse when, by the natural action of the waves, the other would be inefficient. In pitching—if she will ever meet a sea to make her pitch in the ordinary sense of the term—the paddles will be in full action, and so propel the ship when the screw has least power, and in rolling, when the paddles are least effective, the screw will be most efficient.

There are many minor points of great interest to the engineer and shipbuilder. The absence of external keel—the flatness of her floor—her iron and wooden masts—the application of steam power to aid in many of the ordinary duties of the ship—the situation and adjustment of her compasses.

The first difficulty suggested was that of steering. To accomplish this efficiently it is necessary that the captain should be in a position to command a full view of the ship's course, and to communicate at once with the officer at the helm. The post always assumed by the captain in steamers is the bridge near the centre of the ship, but in this ship it is more than 300 feet from the helm, and, without some mechanical aid, it would be impossible to insure that immediate obedience to his orders which is indispensable. This aid is afforded by two dials, properly marked, and two indicators, one moved by the man on the bridge close to the captain, awaiting his orders, and the other answering thereto from the helm. The captain directs the man on the bridge to put the helm "hard a-port," and he immediately brings the indicator before him to the proper mark on the dial, moving, at the same time, a corresponding finger on the dial immediately before the officer at the helm. As soon as the finger begins to move, the officer orders the men under him to move the tiller in the same direction, and this action moves the dial on the bridge, showing that the order is in course of being obeyed, almost before it is fully expressed. By this contrivance the orders of the captain are conveyed 350 feet to the officer of the helm, and are obeyed quickly, quietly, and accurately; thus overcoming the inconvenience of distance, and obviating one of the anticipated difficulties of navigating this large ship. At night these dials are illuminated, so that the facility of communication is fully equal to that by day.

On either side of this steering apparatus are the paddle and screw engine telegraphs. Here, by turning a handle with an indicator, working on a marked dial-plate, a similar indicator is moved in the engine-room, every movement being preceded by the sound of a large bell, which can be distinctly heard over the noise of the machinery; and by these arrangements the rudder and engines, although out of sight of the captain, are as immediately under his command as though he could speak to the engineers and helmsman.

The next, but perhaps, the most important subject for consideration, as regards the safe navigation of the ship, was how to secure, as far as possible, the accuracy of the compass in so large an iron ship; but experience and science have overcome all difficulties, for although the weight of iron in this ship is by several thousand tons greater than that in any other, yet it is so large that the effect of the iron of the ship on the compass can be as easily, and perhaps more easily counteracted than in ships of war or in smaller ships where the compass is more closely surrounded by the iron-work and the armament. Ample means have been taken, by careful adjustment and in the selection of the positions where the compasses are placed, to prevent if possible any disturbance of the magnetic action, and, if any should occur, to afford facilities for watching and noting such disturbance so as to prevent any deviation from the intended course.

We must now consider the results which the engineer anticipated would follow this combination of size and power, and compare them, as we are now in some measure able to do, with those obtained during the trial trips from London to Portland, from Portland to Holyhead, and from Holyhead to Southampton.

Mr. Brunel, when placing his views before competent persons, in 1851, inquired whether, if he could build a ship that should be safer than any ship afloat, that could perform the voyage to Calcutta in 30 or 33 days, and could carry a large number of passengers in comfort hitherto unknown at sea, and 5000 or 10,000 tons of cargo, at clipper rates, sufficient passengers and cargo would be found to make it a remunerative undertaking. The answer to these questions was prepared by Mr. Campbell, the present energetic chairman of the company, and so conclusive were the facts he collected, that a company was formed, and the ship has been built. Public opinion, scientific and popular, has acknowledged the unparalleled strength and safety of this ship, almost without a dissentient voice.

The power to perform the voyage to Calcutta in 30 or 33 days has yet to be tested, but there are facts enough collected to enable us to form a tolerably accurate opinion as to the probability of her success in this respect. Much misconception, owing no doubt to a vague idea of the real distance to Calcutta, to the great length of time occupied by clipper ships and auxiliary steam-ships in the voyage, and the apparently, as compared with them, very short time given to this ship, has got possession of the public mind as to the speed per hour necessary to accomplish the duty undertaken. To give a popular illustration of the speed required, let me compare the time occupied by an express train and an ordinary railway train. It is not that the express engine goes so much faster than that of the common train, but that all stoppages are avoided. So with this ship; it is in her power to run the distance without stopping, or going out of her course to coal, that enables her to accomplish the object in view. The speed proposed by Mr. Brunel in the first published prospectus, in 1852, was that "which experience proves such vessels to be capable of, and which will perform the voyage easily in 32 days." To do this, he determined to employ engines of 2600 horse-power, consuming from 250 to 300 tons of fuel per day, and, in the report just referred to, 15 knots per hour is stated as the required speed.

The trials prove, as far as they go (the engines never having been worked to full speed) that after a little working, when everything is in order, this rate will be attained.

The distance to Calcutta is 11,819 geographical miles or knots.
The time to Calcutta by Peninsular and Oriental ships, 38 to 40 days.
Time to Calcutta *via* Marseilles, 34 to 36 days.
Time to Calcutta by Great Eastern, at per hour:—16 knots, 31 days; 15 knots, 33 days; 14 knots, 35 days; 13 knots, 38 days.

From 12 to 15½ knots have been done with a maximum rate of 12½ revolutions of the paddle and 40 of the screw engines per minute. Give them 16 and 48 respectively, and more than the anticipated duty will be done. So accurately has the speed attained agreed with the printed table of rates prepared by Mr. Russell, that with it in your hand, and knowing the number of revolutions of the engines, you could almost with certainty declare her speed without reference to the log, and this under adverse circumstances, for she has not yet been tried in calm weather and with a fair wind. In comparing her speed with that of our large

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ocean passenger ships supported by large government subsidies, it must not be forgotten that while by this ship it was proposed to accomplish a higher average ocean speed than has yet been attained, it was also calculated to carry so many passengers and so much freight, that it should be worked profitably without subsidy, the sum annually paid by government to mail steamers being £982,000.

In every other fast passenger ship the coals and engines, even for a short voyage, occupy so much of the ship that but little freight can be carried, and only a limited number of passengers in proportion to the size of the ship, and these mainly of the first-class. They occupy the same relative position in ocean travelling to other steamers that the fast coach or mail did to the six insider of former days. The one quick, used only by the rich; the other slow, but paid for by the public. Railways have abolished this distinction ashore; rich and poor travel at nearly the same speed, though at varying rates; and this great ship is the first step in the same direction afloat. Mail coaches required subsidies;—by rail the mail is carried at rates scarcely equal to the actual cost of transit. So the mail steamers now built cannot run without subsidies; and as the rail has beaten the coach, so we hope in this ship to beat the subsidised mail steamers in speed and economy, and thus to secure large public support, which is of infinitely more value than a government subsidy. The one tends to check progress so long as a contract continues; the other stimulates and encourages it, because it rewards every improvement.

At 15 knots per hour this ship will reach Calcutta in 32 days, and at 16 knots in 30 days and 12 hours, with a consumption of fuel, when the aid of trade winds and favourable monsoons is allowed for, not exceeding 280 tons per diem.

There can be no doubt but that if she had more power her speed would be greater; but extra speed can only be attained by the displacement of passengers and cargo; and it is the skill with which the space allotted to machinery, the source of expenditure, and that allotted to passengers and cargo, the sources of income, have been determined, that forms the best ground of our hope that this ship, when the first difficulties of starting so novel an undertaking are overcome, will be a great commercial success. Disturb the one, and the rates for the other two must be increased, and our surest element of prosperity destroyed.

This then is the measure of the advantage gained by her beautiful form, great size, but comparatively small steam-power. We have a higher speed by a vessel 7 or 8 times larger than any afloat, than has yet been attained—capable of carrying from 5000 to 10,000 passengers, or 4000 passengers and 10,000 tons of cargo; burning per hour but three times the quantity of coals now used by ships one-eighth her size, and carrying fuel for 40 days steaming instead of for 15 days. Can anyone doubt this being a great advance in ocean steam navigation? Railway speed was never the object of the engineer; but large carrying power with great safety, at a speed to accomplish the distance to India in the same or in less time than by the overland mail route, with the economy of ordinary clipper ships, was his object; and, as far as we can see, it appears likely to be fully realised.

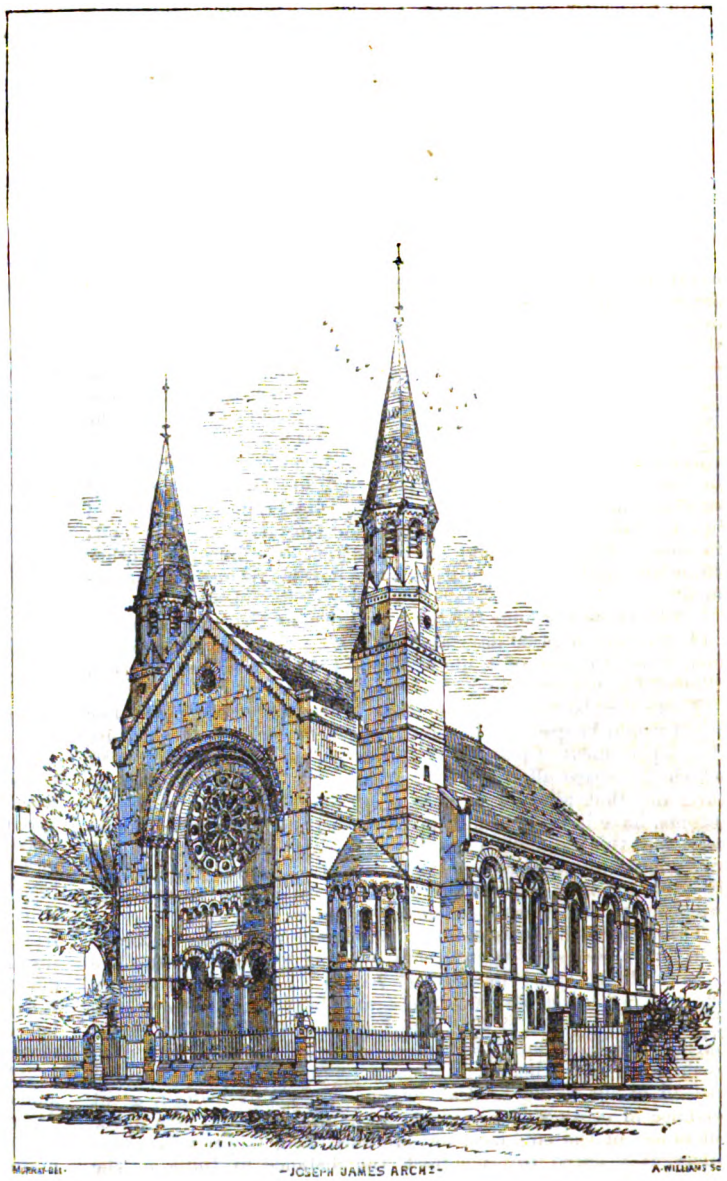
Everyone who has been on board during her trial trips testifies to her steadiness. It has been assumed by some, without any reason, that she would neither pitch nor roll, an assumption displaying a want of knowledge of dynamics, and of what is required for the safety of the ship. This opinion however was held by many when the idea of so large a ship was first announced, and would, were it the fact, be as they asserted a source of danger; for were she so stiff as some fancied she would be, she would receive the full shock of every wave passing her, which notwithstanding her great strength would sorely try her. The rate with which waves are driven along during severe storms has been very accurately determined by Dr. Scoresby not to exceed 34 knots per hour. The highest rate he registered during a severe storm in the Atlantic Ocean, in 1847, was 32·67, and in one still more severe in the Southern Ocean, in 1855, 33·9 knots per hour. The time occupied by a wave in passing the Royal Charter during the storm in 1855 was nine seconds, the ship running forward during the same time 180 feet, by which you can form an idea of ample time for that ship to rise and fall as the waves alternately overtook and passed her; whilst their rate, which in the case of the Royal Charter was nearly three times that of the ship, would be only a little more than double that of the Great Eastern; but whatever these double proportions may be, her motion in the water will be governed by the same laws which regulate that of smaller ships, with this difference in the effect, that as she is larger and more powerful, the waves which would make a Dover packet pitch and roll, as most of us have experienced in crossing the channel, will produce no effect upon her. Let, however, waves be formed which bear the same proportion to this ship as the waves in the channel do to a Dover packet, and the pitching and rolling will be equal; but as this, so far as our knowledge goes, cannot be, so will this ship be easier than any other. Thus we find, during the late rough weather, as she came round the Land's End, with a westerly gale driving in the Atlantic rollers, she rolled only to 8 degrees; whereas Dr. Scoresby, running round the same course to Plymouth in 1855 in the Royal Charter, states that off the Lizard the rolling varied from 20 to 30 degrees, and that in a gale of wind in the Southern Ocean, when the ship was running 14 knots, she rolled 28 degrees to port and 19 degrees to starboard; and that her rolling on her return voyage from Australia *viâ* Cape Horn was much greater, the clinometer indicating, on several occasions, an inclination of 33 degrees to port and 28 degrees to starboard, and on one occasion the time occupied by each oscillation was 50 seconds.

It can hardly be doubted then, that with almost an absence of pitching, and rolling so much reduced as in bad weather not to exceed 8 to 10 degrees, this must be a comfortable ship, and we have a right to regard the superiority of comfort in this over that of any other ship as satisfactorily proved; but while on this part of the subject, I will quote a few remarks of Dr. Scoresby relating to the pitching of the Royal Charter, during very severe weather, and when the waves of Cape Horn were at the maximum height he ever witnessed. The Royal Charter was a ship of 2000 tons burden—326 ft. long, 41·6 ft. beam, and 26·6 ft. in depth—or rather less than half the length and depth of the Great Eastern, and just half the beam. Dr. Scoresby, a very experienced sailor, as well as a distinguished man of science, describes her as the easiest ship he had ever sailed in. He says that in a violent gale, when the ship made 12 and 14 knots per hour, and when the waves were at their maximum height of 40 and 42 feet, the prevailing seas being above 30 feet and 650 feet in length from crest to crest, that there were intervals in which the ship was perfectly steady, and found an even berth. If that be so with a length of 326 feet how much more perfect will be the berthing on the waves of a ship 682 feet long. The height of the waves here referred to was from 40 to 42 feet—20 or 21 feet above the mean level of the water—a height sufficient to wash over even a larger ship if she did not rise to the waves, but which would hardly reach the Great Eastern, the tops of whose bulwarks are more than 30 feet above her load water line. Dr. Scoresby's journal, referring to the motion of the Royal Charter in this very severe storm, states,

"Now as to the action of the Royal Charter under this hard gale and mighty disturbance of the waters. The experience we derived was very astonishing, and, compared with all my previous experience, what I should have deemed impossible.....A minute or two would often pass whilst these mighty waves were rolling harmlessly forward, and but just raising in a slight degree the stern and alternately depressing it, when we might have seemed to be sailing in a sea of extreme calmness in the finest weather. I noticed intervals of from 7 to 8, 10 to 11, and sometimes of from 20 to 24 seconds, when there was not motion sufficient to break the silence of repose like that of a dock or harbour. Thus when the waves were the highest, when elevations of 40 feet and upwards were rolling around and beneath the ship, Mrs. Scoresby accompanied me on deck for exercise, and to view in an instant of bright sunshine the sublime scenes around. Again, in regard to pitching the action of the ship was equally remarkable. A 40-feet wave, on its entrance below the stern whilst the bow was exactly in the most depressed position, betwixt east and west, should raise the stern so as to give an inclination to the keel of 7 degrees, but no such measure of pitching was ever observed, probably not more than half so much. In no instance of scudding did I observe the stern rise to anything like the position due to the elevation of the passing wave. The action was obviously of this nature. From the admirable line of construction forward and aft, the loftiest wave, on its reaching the sternpost below, exerts its lifting force not abruptly or suddenly, as when the quarters were heavy and the run thick, but very gradually, so that the disturbing force passing rapidly beyond the place of greatest influence before its due action is realised, becomes modified and reduced."

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NEW CONGREGATIONAL CHAPEL, NORWICH.



This chapel is one of the best and prettiest buildings in Norwich. Its width is 47 feet 8 inches; length 86 feet; width of nave, 28 feet; height of nave, 43 feet; and height of side vaults, 28 feet. Comfortable sitting room is afforded for 900 persons.

The arrangement of the interior is of a somewhat novel description. The width is divided into a nave and aisles by the introduction of iron columns instead of stone, which is generally used, and thus a nave is obtained between the columns, which are carried quite up to the roof timbers, the latter being greatly relieved and economised by two additional bearings. The roof of the nave is ceiled in a semicircular shape, being what is generally termed a wagon-headed ceiling, and is finished at the pulpit end by an apse circular on plan, which, with four stained glass windows of a neat pattern, gives a pleasing appearance to this part of the building. The length of the nave is divided into five bays by the iron columns, from which spring arches formed in bracketing and plaster. These arches are consequently at right angles with the nave, and being carried to the side walls give five distinct vaults on each side. In the centre of these vaults are the principal windows of the chapel, which consist of two single-light windows, circular-headed, with a bull's-eye above and between them of the same diameter, under a continuous hood mould. The pewing is arranged in the usual manner, and is worked in pitch pine and varnished. Across the apse is placed an ornamental screen, panelled, and pierced with openings of the same character as the side windows. These openings are glazed with ground glass and finished with iron transoms and twisted uprights in the centre of each. In the centre of the screen is a doorway leading from the vestry into the pulpit, the stairs to which are behind. The pulpit, which is larger than usual, is carried out to accord with the details of the screen. In front of the pulpit is the communion table and chair, with two benches on each side for the deacons, the whole of which are placed on a raised dais of two steps; and behind the screen are a vestry and other conveniences with separate entrances. In the front of the chapel admirable arrangements have been made for ingress and egress; the entrances to the galleries and the body of the chapel have been judiciously kept separate; and there is also the further accommodation of an additional door on each side, which is opened only when the congregation leaves the building.

The exterior is of a neat and substantial character, and is generally carried out with moulded brickwork from the Cossey Fields. The principal feature in the front is a projecting gable, the width of the nave, in which is a deeply recessed arch, formed of Norman piers, caps, bases, and arch mouldings. In the centre of this is an elaborate catherine-wheel window, of a more foreign type of Norman work than is generally found in England; beneath is a small arcade, under which is an open porch formed of three Portland stone arches, and columns with caps suitably carved. On each side of this centre gable is a small circular staircase to the galleries.

The contract was taken by Mr. H. Sexton, of Norwich, and the outlay—inclusive of the land, lighting, boundary walls, iron palisading, drainage, but exclusive of professional fees was £3300. The works have been carried out under the superintendence of Mr. Joseph James, architect, Furnival's-inn, London.

Restoration of Chichester Cathedral.—Works are in progress in this building by which the cathedral will be thrown open from end to end, and the space which hitherto was available only for about 250 adults will be increased so as to accommodate 700 or 800. It has been necessary to separate the nave from the choir during the alterations. The restoration will be carried on under the superintendence of Mr. William Slater, architect, as rapidly as possible. The outlay is estimated at about £6000, of which a considerable sum will be required for permanent masons' work. More than £8000 has already been spent upon the exterior of the building in the lifetime of the late dean.

INSTITUTION OF CIVIL ENGINEERS.

JOSEPH LOCKE, Esq., M. P., President, in the chair.

Nov. 22, 1859.—The whole of the evening was occupied by the discussion, commenced at the last meeting, upon Mr. Amos' Paper, "*On the Government Water Works, Trafalgar-square.*"

It was remarked, that the main point sought to be established in the paper appeared to be, that an abundant and reliable supply of water could be obtained from these wells; whilst it was admitted that very different results had taken place at various other establishments where attempts had been made to procure a large and permanent supply of water from the sand and chalk under London. Now, it had been contended for many years past either that a large supply could not be pumped from the chalk, or that if it was, mischief would be done in other quarters. It had been argued that, from an aggregate of causes, a general depression of the water-level under London had been produced. This opinion was confirmed by the case under consideration, for it was stated in the paper that the water in the wells had originally stood at 48 feet below T. H. W. M., whilst now it was 66 feet below that datum. It had been concluded that there was an infiltration from the river Thames, because it was found that the depression under London was extending more rapidly towards the north than at the centre of the greatest abstraction by pumping; and it was believed that the depressed level rose towards the tidal outfall. In a paper which was read at the Institution in May 1855, it was shown by the analyses of different waters, especially from the wells at Trafalgar-square, that there was a larger amount of saline matter than was ordinarily found in chalk water; and it was argued that filtered Thames water was being pumped from the Trafalgar-square wells.

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It was a well ascertained fact that tidal water did find its way into wells sunk below the level of the tidal outfall. This was the case at Ramsgate, at Liverpool, and at Portsmouth. One of the wells at Haslar Hospital having become infected with salt water, an inquiry was instituted, when it was found that the salt water came through a sand beneath the subjacent clay, into which the tidal water found its way from an artificial cause. This evil had now been remedied by shutting out the tidal water and sinking the bore-pipe to a lower stratum.

In confirmation of the opinion as to the general depression of the water level under London, it was stated that brewers and others had been obliged repeatedly to lower their pumps. This plan had been recommended in the case of the Covent-garden well, but it was decided to sink a pipe, 3 inches diameter, deeper into the chalk, in the belief that an inexhaustible supply would be reached. No water was however obtained, and the pumps had to be lowered, as at first proposed, after an unnecessary and useless outlay of money. The pumps were 15 feet or 20 feet higher than at Messrs. Combe's, so that it was necessary to commence pumping early in the morning, or else the water would be down too low. On one occasion, a further supply of water being required by Messrs. Combe, they were persuaded to sink an additional well, with a view of reaching what was termed the "back-bone" of the chalk, and to shut out the sand-water. The failure which arose was predicted. Subsequently, by boring holes from the cylinders into the sand formation, a supply it was said of 70 gallons per minute was obtained. In consequence of the discovery that the water in this well was gradually lowering, daily gaugings had been taken for the last thirty-two years of the rise and fall of the water. From these observations a diagram had been constructed, which had enabled a prediction to be made in 1846 that the well would be dry in 1857, and it proved correct. Another diagram was also exhibited, showing the monthly rainfall over the same period.

On the other hand it was contended that the paper distinctly stated that the level of the water in the Trafalgar-square wells had not been permanently depressed, but that, on the contrary, the water stood at the same height in December 1857, as it had done in December 1847, notwithstanding the large quantity of water pumped in the interval. That there had been variations in the level was not disputed, for after a heavy rainfall or much snow in the winter, the water in the wells increased in the following spring, and under opposite circumstances the level of the water fell. It was believed, that when wells were properly made and sunk, in suitable localities, into the chalk, the water would stand for a series of years at the same level as when the wells were originally sunk. Two analyses made by a competent chemist at a long interval of time also showed that the water from the Trafalgar-square wells contained less saline matter than formerly. With regard to the statements, as to the general and permanent depression of the level of the water in all the wells in the chalk, in the north of London, it was advisable that the situation and particulars of the wells in which this had been noticed should be given, and also the quantity of water daily pumped, and the manner in which the observations were made. Unless these assertions were corroborated in this way, not by an isolated instance, but by numerous examples, they did not prove much. It had been urged that it was impossible to get a large supply of water from the chalk. To this it was replied, in 1853 a company was formed to supply Charlton, Plumstead, and Woolwich from that source, when, from a single well, 600,000 gallons per day had been obtained. In 1857, a new bore-hole 18 inches diameter was carried down from the bottom of the well to a further depth of 500 feet, by which the supply had been increased to 1,000,000 gallons per day, and yet the water stood at the same level as at first. The Kent Waterworks Company had followed this example, and had sunk a well from which upwards of 1,250,000 gallons per day had been pumped without producing any effect whatever upon the supply to the Plumstead works. Another well was then sunk, not 500 yards from the first, the yield from which exceeded 1,500,000 gallons per day; and the two together produced upwards of 3,000,000 gallons per day, yet the level of the water remained the same. Thus a large district of the metropolis was supplied with water from the chalk, and the water was practically free from salt (chloride of sodium), containing no more salt per gallon than the Thames water above Teddington-lock.

It was explained that the water of the Plumstead well was undoubtedly derived from the chalk; but the London basin did not extend so far, being interrupted by a fault, or faults, so that no fair comparison could be instituted between the wells under London, and those at Plumstead. Also, that analyses of the water from the Trafalgar-square wells showed the presence of 79·9 grains of sea-salt per gallon, and little or no carbonate of lime, thus proving that it was sand and salt water, and not chalk water.

It was thought that the paper failed to give information on several points on which explanation was much needed. From 1844 to 1856 it had been publicly contended, that at the Trafalgar-square wells no water came from the sand, but that it was derived entirely from the chalk. The increase in the supply, amounting, it was said, to 600 gallons instead of 100 gallons per minute, had been attributed to the enlargement of the far extending fissures of the chalk. If this was the case, it had been found by calculation that 100 gallons per minute, at atmospheric pressure, passing through say 20 miles of chalk fissure, would require a bore-pipe 9 inches diameter; whereas the actual bore-pipe was only 7 inches diameter. And to admit the increased supply of 600 gallons per minute, this pipe ought to be 19 inches diameter. The quantity of chalk which must have been displaced under such circumstances was enormous, and yet no account had been given of it. The members should also have been told, that in driving the tunnel between the two wells, owing to the want of proper precautions, the sand spring burst in, and nearly drowned the well-sinkers. It was thought the blowing of sand which took place in sinking the second well did not arise, as had been alleged, from the screws which held the joints of the pipes being shaken out, but from the excess of pumping over a limited area. It was not until after some days' pumping of sand into the cisterns of Buckingham Palace and elsewhere that this fact was discovered. It was asserted, that the wells in Orange-street and Trafalgar-square were not exceptional to the general laws governing the rise and fall of waters. They were sand and not chalk spring wells, so that the water supplied to the Palace and Government Offices was not pure chalk water, but was derived from the sand, and was partly saline.

It was stated that since 1832 the pumps in a well in Cowper-street, City-road, had to be lowered twice, the water-level having sunk at least 30 feet, though the quantity of water pumped had remained the same.

Mention was made of the abundant supply of water in the chalk at Ipswich. There was a large tract of rising country behind, and the chalk cropped out on the upper side of the river Orwell, into which considerable streams of fresh water ran.

It was stated that the town of Colchester, containing about 20,000 inhabitants, had since 1851 been supplied with water from a well, and a boring into the chalk to the depth of 390 feet from the surface. The quantity raised averaged 1,250,000 gallons per week, but more could be obtained if necessary. There had been no apparent diminution in the yield, and the water stood at the same level as it did nine years ago, which was about 5 feet above high-water mark.

An account was then given of a deep boring recently prosecuted at Harwich, for the purpose of obtaining an adequate supply of fresh water for the inhabitants and for the shipping frequenting the harbour. Harwich was situated immediately upon the sea-coast, about 18 miles in an easterly direction from Colchester, and 12 miles in a southerly direction from Ipswich, at both of which places an abundant supply of water had been derived from the chalk formation. Many unsuccessful attempts had been previously made, due, it was believed, to sufficient care not having been taken to shut out the salt water. It was therefore determined to use cast-iron pipes with water-tight joints, and to sink them sufficiently deep into the chalk to shut out the salt-water. Pipes 10 inches diameter, and in lengths of nine feet, were employed, and these were forced down 50 feet into the chalk, by which it was hoped that the salt water would be prevented from descending into the bore-hole. The boring was then prosecuted, with a view of reaching the deep springs which had been ascertained to exist in the chalk at no very great distance; but the only result was salt water of precisely the same character as that in the harbour and the sea immediately adjacent. The cylinders were then forced down to a depth of 480 feet, and the boring was continued, without any fresh-water spring being apparently tapped, as the bore-hole remained filled with salt water. The expedient was then resorted to of pumping out the salt water, but it flowed in again as fast as it was withdrawn. The boring was then continued, without any better results, to the upper green sand, and subsequently through the gault to the lower green sand, which was the same stratum that supplied the great boring at Grenelle, in the Paris basin. A few grains of coloured sand mixed with gault were met with, giving indications of the existence of this formation, when suddenly an extremely hard rocky stratum was encountered. It somewhat resembled slate, having a line of cleavage with bed-joints dipping considerably, and containing no fossils. The work was then abandoned, and the boring remained in that state at the present time, the water in the pipe ebbing and flowing with the tide.

The surface of the ground where this boring was made was 6 feet above high water, the chalk being met with at 74 feet below it. At Colchester the chalk was 121 feet below the same datum. The peculiarity which had been noticed in the stratification, and the failure in finding fresh water, could only be accounted for by the supposition that there was a local fault within a short distance. A similar unsuccessful attempt had been made at Walton-on-the-Naze, about 6 miles from Harwich.

It was mentioned that in the West of Ireland, at a place about 13 miles from the sea, a well had been sunk through the cavernous lime-stone. The shaft was 9 feet diameter, and from 50 to 60 feet deep. A supply of water was obtained, but as it was not sufficient, an auger-hole 3 inches diameter was inserted to a further depth of 30 feet, or about the level of the sea, and far below the possibility of drainage by the adjacent rivers, when the water entirely disappeared. In that district rivers disappeared for a distance of 3 or 4 miles, and then reappeared upon the surface.

It was considered that it was most objectionable to derive the supply of water for the metropolis from the river Thames, and that if practicable some other source should be resorted to. The large demands already made by the metropolitan population upon the waters of the Thames had during dry seasons tended to injure the navigation by reducing the scour, and of late years the abstraction of water from the Thames had been

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greatly increased, as appeared from the returns of the water companies. It therefore became important to ascertain whether that portion of the rainfall which was absorbed and percolated into the chalk beneath London and did not reflow into the river Thames, might not be made available for the supply of the metropolis, without reducing the quantity of fresh water flowing down the Thames, or becoming injurious in other respects. Supposing that 8 inches of rainfall per annum descended into the chalk basin surrounding London, a bare statement of facts showing that certain wells were being depressed whilst others were not, was not deemed sufficient upon which to base an argument that an important source of water supply might not be derived from the chalk formation, or that the present injurious demand upon the waters of the Thames should be continued.

It was remarked, that in the new red sandstone, the coal measures, the chalk, and other geological formations, the great volume of water existed in the strata between 300 feet and 900 feet deep. Therefore, the idea of getting a larger quantity by sinking deeper was fallacious. Great caution should be observed in relying upon a supply of water from wells for large communities. Ancient Rome, New York, Liverpool and Manchester, had originally been supplied from wells. But in all these cases the local wells had to be abandoned, or else to be largely assisted, by going to sources where the water was on the surface. At the same time, wells should not be wholly repudiated for small populations. In reference to the remarks which had been made as to wells near the sea coast, the well at Worthing was alluded to. It was situated at less than a quarter of a mile from the sea coast, and where the surface of the ground was about 30 feet above high-water. The surface water was tubbed out by cast-iron cylinders for a depth of 70 feet, and then the chalk was bored into for a depth of 295 feet. About 150,000 gallons per day were pumped, and as yet there had been no perceptible diminution in the quantity, nor was the water at all salt. It was believed that the strata of the district were capable of yielding a much larger quantity.

The experience obtained in sinking a large number of wells into the chalk went to show, that a variation in the water level might always be anticipated, according as the previous season had been wet or dry. This would not be conclusive where the water was being drawn from wells much below the natural outfall or the level of the sea. In those cases it was apprehended that the rise or fall would depend on the extent of the water-bearing strata within the influence of the pumping.

In reply to some of the statements which had been made in the course of the discussion, it was observed that the supply from the Trafalgar-square wells had not been increased at one time. At first 100 gallons per minute were thought sufficient. When a larger quantity was required 300 gallons per minute were obtained; and now 600 gallons were pumped. It had been stated in the paper, that the abstraction of that quantity had lowered the water 24 feet, beyond which it could not be depressed. A daily record had been kept during eleven years of the height of the water in the wells, and the highest and lowest levels at which the water stood in each of these years were given.

After the meeting Mr. John Poole exhibited and explained a "*Parallel Motion Safety Valve.*"

It was pointed out that the ordinary valve simply rested on its face or seat; its vertical or upward motion being guided by a spindle on the lower side, passing through a box or feathers in the steam-pipe. The area of the discharge pipe was thus reduced one-third, and in some cases as much as one-half. This valve was pressed upon by a weighted lever, moving on a hinge or centre on one side. When in a state of rest, the lever and the centre of the spindle were at right angles to each other; but as soon as the valve rose the angle became more acute. This brought an unequal load upon the valve, and caused friction, inducing a tendency in the spindle to twist, and in the valve to jam or stick. The guide spindle, being below the valve face, was also liable to be corroded by foul or dirty water, and to unequal contraction and expansion. It was likewise found that these valves, when out of order, invariably leaped on the side nearest the hinge of the lever.

In the "Parallel Motion Safety Valve" the spindle was on the upper side, the seat or face was flat, and the discharge pipe was free of interior incumbrances, so that less leverage and weight were necessary. The spindle passed through a guide above, and to the centre of the spindle on which the valve was hinged the parallel motion was attached. It was shown by a sectional model that the radial action of the lever did not control the vertical action of the valve, which therefore could not stick or jam in its seat.

Nov. 29.—Paper read, "*On Arterial Drainage and Outfalls.*" By R. B. GRANTHAM, M. Inst. C.E.

The author commenced by giving an extract from Mr. Simpson's address, delivered in January 1854, describing the general state of many important districts in which property to a large amount was rendered useless, from the want of a proper system of arterial drainage, and of the improvement of the trunk lines, or principal water-courses. The legal difficulties in the way of carrying out works of this character, led the author to think, that some general legislative measure was necessary—such as Earl Carlisle's Bill, proposed in 1852, which, in his opinion, was the best that had been suggested—before the great object of improved arterial drainage and outfalls could be attempted on a comprehensive scale, or be effectively maintained in working order.

The subject was treated under the following heads:—First, attention was called to some of the evils arising from the want of a combined system of operation. Secondly, an account was given of the impediments which exist to prevent the adoption of arterial drainage. Thirdly, the class of works necessary to be carried out was described. And lastly, some of the leading principles in the construction of drainage works to accomplish the object in view, were pointed out.

The paper then went on to state, that there was perhaps scarcely a district in this country where one of two conditions did not exist; either the lands could not be drained at all, or they were injuriously affected by the drainage of those above them. Instances were given in illustration of these two conditions; and it was remarked, that in many cases a single person who was unwilling to drain his property might prevent any improvement by adjoining owners.

Owing to the extensive system of subterranean or pipe drainage, and to the field drains and ditches being better cleared out than formerly, there had been a large increase in the water flowing down rivers, brooks, and minor streams. The effect of this was, that the water was discharged in a shorter time, causing more frequent floods, as the brooks and streams were of inadequate size; and at other times, the rivers and streams contained less water than formerly, in many cases not sufficient for the supply of the towns and country dependent on them. To give some idea of the magnitude of this system, it was stated that, within the last ten years, about four millions sterling had been expended in the drainage of 800,000 acres, under the control of the Inclosure Commissioners of England; and it was estimated, that probably twice that amount had been laid out by the crown, by corporate bodies, and by private individuals. For full details of the progress and results of the under-drainage of land in Great Britain, the members were referred to Mr. Bailey Denton's paper, read before the Society of Arts in Dec. 1855.

The tendency of mills, weirs, dams, and other obstructions in rivers, as well as the crooked and confined channels of the rivers themselves, to impound the upland waters, was next adverted to. And on the other hand, the injury which lands suffered by being inundated by the drainage of the uplands, from the want of combination among the possessors of property, was shown. Both these cases were illustrated by a proposed drainage in the vicinity of Wareham, Dorsetshire. This had been designed by Mr. Simpson, principally with a view to the improvement of the marsh land belonging to the Earl of Eldon's estate there. After describing the character and peculiarities of the district, which was situated chiefly on the borders of the North and South rivers, and stating that the marsh land was 3000 acres in extent, of which it was proposed to include 2550 acres, the paper went on to allude to the provision made by the respective landowners for the lower drainage. No attempts had ever been made to divert the upland streams, which frequently caused great damage during floods, and permanently retained the water in the ditches of the lower drainage at a higher level than it would otherwise be from the tidal drainage. As the country above Wareham, on the banks of the river Frome, rose gradually inland, facilities were afforded for drainage by gravitation, and the proposed works were arranged so as to discharge by outfalls, continued down the side of the river, to a level sufficiently low to prevent the lands being injured by backing up the water during floods. It was also intended that the river should be properly embanked, to confine the flood waters to its channel. As it was found that it would be impossible to depress the water in the ditches sufficiently low to admit of a natural outfall, mechanical aid had to be resorted to. This was intended to be used in conjunction with upper and lower reservoirs, in order to reduce the pumping to a minimum, and to economise the cost of construction and of working. Provision was also made for the reclamation of upwards of 500 acres of mudland from Wareham Harbour. The effect of straightening and deepening the river below the bridge would undoubtedly have improved the navigation. The cost of carrying out this scheme was estimated at £22,000. It would have involved an average annual charge of seven shillings per acre on the whole district, to provide for interest of capital, and for the cost of working and maintenance, after deducting the annual value of the reclaimed land.

The impediments which at present exist to prevent arterial drainage being carried out on a combined system were attributed mainly to the state of the law, which required to be modified and changed, and its powers enlarged and liberalised, as had been previously stated. The points which more immediately concerned the engineer were, the straightening and deepening both internal and tidal rivers, and the removal of mills, dams, weirs, and other obstructions, in order to produce uniform inclinations towards the outfalls of streams. The gradients or inclinations must be adapted to the soil through which the rivers flow, to obviate the scouring action of the water on the banks and bottoms of their courses. It was also necessary to impound the surplus water, so as to preserve an uniform minimum supply to the channels of rivers at all times; to provide works available to take off field drainage, and for the irrigation of adjoining lands, for the re-construction of bridges and culverts under public roads, and for the application of the water to the supply of towns and villages, which in many instances might be altogether deprived of their supply by any thorough system of drainage.

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The arterial drainage and outfall works executed in Ireland since 1846, the year of the famine, were then alluded to, as forming the best examples of such works in the United Kingdom; although some were imperfectly projected at first, owing to the hasty manner in which they were necessarily undertaken, and the cost had much exceeded the original estimates. The report of the government commission, consisting of Sir Richard Griffith, Bart., Sir William Cubitt, and the late Mr. Rendel, appointed to inquire into twelve of the districts, and which was published in 1853, gave a full account of all that had been done up to that time. It stated, that the works exceeded 385 miles in extent, and that the catchwater basins comprehended an area of 1,139,182 acres, of which about 77,546 acres were liable to injury by floods. The great defect of this system was, that no provision was made for maintaining the works and keeping them in repair after the first year. A large amount of money was also expended in works for improving and in some cases creating water power, which proved totally useless, and was inconsistent with the primary object of the drainage schemes.

Probably the largest work in the world, in reclaiming an extensive area of country from the effects of stagnant water and floods by arterial drainage, was that in the Fen districts, commonly called the Bedford Level, to which attention was next directed. This enormous tract of land was originally a freshwater estuary of the Wash,—for many ages the sole characteristic of the Fens,—into which the rivers Witham, Welland, Glen, Nene, and Ouse were discharged. Having given the general character of the Fens, and of the rivers discharging into them, the author then described what had been their state, and the means which had been adopted to reclaim and raise them to their present valuable and flourishing condition.

The Bedford Level was divided into three parts, called respectively, the South, the Middle, and the North Levels. Commencing with the South Level, the effect of the first Denver sluice, which was carried away in 1713, in damming up the waters of the Bedford river, was referred to. This sluice was rebuilt by Labelye in 1750. The Eau Brink Cut was executed under an act passed in 1795; but it was not until after the lapse of twenty-one years that the works were commenced, and it was only in 1821 that they were opened. By means of this cut, the general drainage of the country was benefitted, the low water was depressed 7 feet at its upper end, and the navigation was improved up to and in the harbour of Lynn. The cills of the Denver sluice were thus enabled to be lowered 6 feet, which made a manifest change in the whole of this level. The cost of these works amounted to £600,000, which was rated upon the lands drained by the rivers having their outlet into the Ouse. The number of acres so rated was 250,000, including a portion of the Middle Level.

For a great number of years the North Level was suffered to drain by the crooked course of the old Nene river. The first attempt at improving the outfall was proposed by Kinderley, in 1721; but it was not until 1770 that a cut was made, and then only to the extent of one-half of what had been suggested. Sand-banks continued to increase in the Wisbech river, until the navigation was totally destroyed for large shipping. At last the corporation of the Bedford Level instructed Mr. Rennie "to report his opinion on the Wisbech outfall, and the drainage of the extensive washes lying between the two branches of the Nene; as also the North Level, &c." This report, which was made in 1814, recommended that the river Nene should be deepened and widened, and that a new channel should be made from Kinderley's cut to the level of low water in the bay at Crabhole, so as to improve the outfall. Owing however to the distressed condition of the agricultural interest at that time and in the following years, nothing was done. Subsequently, it was suggested that a bridge should be built, and an embankment be made at Sutton Wash, so as to establish a direct communication between the counties of Lincoln and Norfolk. All these works were afterwards carried out, under an act obtained in 1827, through the perseverance of the North Level Commissioners. The water was turned through the new passage in June 1830, and the result was most successful. The cost of the cut, or new channel of the Nene, from Kinderley's cut to Crabhole, was £200,716. As soon as this work was accomplished, the internal drains were adapted to the new state of things. A sluice was constructed to discharge the waters of the level into the Nene, the cill being laid 5 feet lower than would formerly have been possible. The main drain up to Clough's Cross was formed 8 feet deeper than the old Shire drain, and six times its capacity; and from Clough's Cross two new drains diverged, called the New South Eau and the New Wryde. These works were opened in 1834, when their efficacy was fully proved. The total sum expended upon them was £100,000; this had fallen upon the land, the area drained being 200,000 acres. That the money had been well spent was proved by the fact, that land which in 1828 was only worth £5 per acre, twenty years later brought from £60 to £70 per acre.

The Middle Level presented the most complicated system of drainage in the whole of the Fens. The principal artery of this area was the old river Nene. This had been allowed to become useless as a navigation, and was little better as an arterial drain. The remedies applied in 1795 were merely temporary expedients. In 1800, when matters were at their worst, Mr. Rennie was consulted. He reported again in 1808, and advised that the Eau Brink Cut should be made, as a preliminary necessity, and that then the whole Fen should be surrounded with catch-water drains, carried along the foot of the high grounds, so as to intercept all the waters that would otherwise spread themselves over the Fens. The two Bedford rivers were to be converted into one,—a new cut was proposed from Whittlesea Mere, and a drain was to be carried to Grunty Fen. The estimated cost, one million sterling, so alarmed the landowners, that, though damage to that amount had been done in the spring of 1807, owing to the want of some such works, this design was never carried out. In 1836 Sir John Rennie was consulted, and was instructed to report on the defects of the drainage and navigation, and to advise as to the best method for removing them. Several other engineers also surveyed and reported upon plans for improving the drainage of the Middle Level, but still nothing was done. It seemed that there were two different plans for providing an outfall for the southern part of the Middle Level. Sir John Rennie advocated that at Sutton Bridge, whilst others were for draining into the Ouse. The proprietors next consulted Mr. James Walker, who reported in 1842. He proposed that the drainage should be separated from the navigation, and that the present rivers and drains should be carried over the main drains, which he suggested should be made straight through the Middle Level. It was determined, in 1847, to make a main drain, now called Walker's Cut, to commence at the upper end of the Eau Brink Cut, above the marsh-land sluice to Caldecott Farm, on the west side of Whittlesea Mere. At first the bottom was made 50 feet wide at the lower end, 40 feet at its junction with Well Creek, and 30 feet above Well Creek; the level of the bottom being 5 feet below low water in the Ouse at the outlet. In 1848 it was decided to deepen nearly all the main drains and rivers of the Middle Level from 4 feet to 7 feet, and to increase the bottom widths from 12 feet to 30 feet. These works were completed in 1852; and they had enabled the water in the rivers and drains to be lowered 6 feet. The cost amounted to £410,000. In 1857 it was determined to deepen Walker's Cut by 4 feet. Each step that had been taken in the improvement of the drainage, since 1842, had been attended with the most satisfactory results. The best proof of this was, that the money, which was raised by taxation, was collected without difficulty.

The author then referred to the means adopted by the Norfolk Estuary Company for the reclamation of land; and next to the Ancholme Drainage, an account of which was presented to the Institution, in 1845, by Sir John Rennie. In this paper, as well as in all that had been introduced relative to the Fen district, some of the leading principles of the drainage of level areas, and of improving rivers in flat countries, were noticed. These were, first, the formation of catchwater drains for intercepting highland waters; secondly, separating as much as possible navigation from drainage, in improving rivers; thirdly, the slopes or inclinations that the bottoms of rivers or newly cut drains discharging into tideways, should be formed to; fourthly, the depth at which the cills of outfalls into tideways should be laid; and lastly, the formation of overfall weirs and reservoirs, for the retention of mud and sand.

Some large drainages in Yorkshire were then referred to, and it was mentioned that an estate of about 2250 acres, at Thornton, near Pocklington, was at this time suffering considerable injury, from the want of facility for draining the water from it.

When Hainault Forest, lately a royal forest, was disafforested in 1853, the allotment made to the crown contained about 2000 acres. This consisted of a level plain, part of which was known as Fairlop plain, lying at the foot of a ridge of land sloping towards the south. Another ridge projected into it from the east, and at the foot of these ridges were valleys, which brought down the water from beyond the limits of the crown allotment. The first operation in the reclamation was that of making the roads and arterial drains. The three principal valleys were the Dog Kennel Brook, extending from Little Heath, on the southern boundary of the allotment, to the northern boundary, where it branched towards the north-east;—the Well Ridden Brook, branching off from the Dog Kennel Brook about half a mile from Little Heath, and towards the north-east;—and a main drain on the opposite side, which received the drainage of the west and north-west parts of the allotment and of the lands to the north of it. In each of these valleys regular open drains had been formed, into which all the pipe drains were discharged. The Dog Kennel drain was 6 feet wide at the bottom, and from 4 to 5 feet deep at the outlet; the bottom width diminishing gradually to 2 feet at the upper end. The inclinations were 1 in 528 for the lower part, and from 1 in 125 to 1 in 200 for the upper part. The natural fall of the valley was steeper than this. Therefore, overfalls varying from 3 feet to 10 feet in width of opening, and from 3 feet to 5 feet rise, were constructed of brickwork at different points. These were capable of being made into dams, by inserting boards into grooves, for storing water in dry seasons, for cattle or other purposes, and for irrigating the land on both sides. The system adopted was to have as few open drains as possible, and large mains. The area of land gained for profitable cultivation was thereby increased, and the labour of tillage reduced. It was found that the agriculturists neglected the mouths of under-drains if they were numerous, so that it was good economy to reduce the number to a minimum. This forest, which from time immemorial had been almost a waste, was now a valuable farm; and what was formerly a refuge for thieves and poachers, now afforded the means of profitable employment to many persons.

The author then proceeded to refer to the manner of dealing with

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rivers in India and in Northern Italy, quoting principally from the published works of Capt. Baird Smith, M.E., and Paul Frisi. The tanks or reservoirs which abounded in the Madras presidency might it was believed be connected with arterial drainage works, especially in rapidly inclined countries, and be useful as aids to agriculture, and for the supply of towns. In upland or internal rivers and streams, such as those last alluded to, the leading principles to be observed in their improvement were—first, straightening the channels from the source to the outfall; secondly, making them of sufficient width to include all the flood waters, having regard to the inclinations; thirdly, the formation of shallow rather than deep drains, in nearly all kinds of soils; fourthly, the regulating or adjusting the inclinations of the bottoms, so that the velocity of the water might be checked, to prevent the erosion of the sides and bottoms, and the removal of the gravel, sand, and mud to the lower levels; and lastly, providing the means of storing up the water in reservoirs or tanks, apart from drainage, at convenient points, for agricultural and industrial purposes.

The paper concluded by noticing the Commissioners of Sewers, first instituted in the reign of Henry VI., who were acting in every part of the country, having jurisdiction on the borders of the sea or tidal rivers. Their duties were to repair sea or river banks, and to keep the main drains and outfalls of level districts in repair, and clear them for the passage of water. Their powers were not sufficiently extensive, and it was stated that their constitution would have to be remodelled in the event of any fresh legislative measure being carried upon this subject.

REVIEWS.

Rifled Ordnance. By LYNALL THOMAS, F.R.S.L. London: J. Weale.

This, as the title-page informs us, is "a practical treatise on the application of the principle of the rifle to guns and mortars; to which is added a new theory of the initial action and force of fired gunpowder." The subject unhappily is of so much interest and importance at the present day, that we shall devote a somewhat larger share of our columns to the review of Mr. Thomas's work than is our usual wont to books like this, which treat on the best means of mangling and slaying our fellow-creatures, and disfiguring God's image as set forth in the likeness of mortal man. We had hoped that the great world-gathering of the peoples—now some ten years ago—to the peaceful tournay of contending art and science, within the crystal walls of that fairy palace,—itself a wonderful trophy of the cunning and prowess of human thought, had been the inauguration of a long period of peace, a solemn act on the part of the assembled nations, declaring that henceforth the only warfare permissible to civilisation should be the emulous strife of energy vieing with energy, and of genius with genius;—a war, of which the march would leave behind it—not wasted fields and burning hamlets, and blackened carcasses, but rich crops where there were none before: and where once the silent wilderness, now the roaring of the loom, the city hum of busy life;—a war, of which the prize would be—not the empty vanities of broken weapons and torn banners, but those more splendid and precious dowries of conquest, wrung from vanquished nature by the victorious armies of labour and of art, such as the steamship and the railway, and that yet mightier and more wondrous electric wire-nerve, which spreads its network from land to land and from sea to sea, and converts the unliving earth into a living body, of which the soul is the united intelligence of mankind! These hopes, how far from being realised they have been we need not say: since that period wars more bloody for their brief duration than were ever before chronicled, have degraded to a by-word and a jest the vaunted humanity and civilisation of the 19th century. However, such considerations as these are beyond the pale of our journalism: let us turn, though with a sigh, to the consideration of the volume before us.

We can hardly hope within the necessary limits of a review to give our readers more than a mere outline sketch of the principal facts and experiments described and commented on by the author, nor attempt to follow him into his minute detail of shot and shell, several of which are his own inventions, and of which copious plates and illustrations are presented to us throughout the volume. The first great consideration in the theory of gunnery must be to obtain accuracy of flight in the projectile, and the only means known of insuring this is by rifling the gun; there can be no doubt that if any *very* considerable range combined with an assured aim be desired, the gun, be it great or small, musket or field-piece, or of siege artillery, must be rifled. The object of rifling is obvious: it is to cause the ball to rotate on an axis, which shall as nearly as possible coincide with a tangent to the line of flight during the motion, and in so rotating compensate for the want of perfect symmetry of its figure, by at every half turn exactly reversing the disturbing forces from the resistance of the air on the line of flight which the want of symmetry would occasion; thus the line of flight becomes approximately a straight line or a line lying at all events in one vertical plane; but more approximately still, an elongated spiral, of which the axis is nearly a straight line lying in a vertical plane. Now if the projectile were perfectly symmetrical about the axis of rotation, and the axis of rotation were coincident with the direction of projection, there would be no tendency at first, and until the downward velocity due to gravity became sensible, to change either the axis of rotation or its direction; for the axis being in all practical cases an axis of greatest or least moment, and no forces acting upon it tending to change the direction of rotation, (the only effect of the resistance of the air being by tangential resistance to diminish the velocity of rotation,) the rotation would be stable about the axis of the projectile; but this state of things would endure only until the velocity of descent was sufficient to occasion a sensible resistance not in the direction of the line of flight, and in this way new moments would be brought into play tending to make the projectile change both the instantaneous axis and also its direction in space. If the centre of gravity of the projectile were sufficiently forward, so that by far the greater amount of surface lay behind it, it is clear that the balance of the moments of resistance would tend to depress the vertex of the projectile and cause the direction of its axis to follow and always *nearly* coincide with that of the line of flight, the instantaneous axis itself would be slightly changed, and deflected out of the vertical plane; but as the angular velocity due to these moments of resistance would be almost infinitely less than the impressed angular velocity about the principal axis, this would still very approximately coincide with the instantaneous axis, and both very nearly with a tangent to the line of flight. This, then, is evidently an important condition, that the centre of gravity of the projectile should be as forward as possible, and this condition and the reasons for it have been well and forcibly brought forward by the author in the chapter on the projectile.

Another condition is, that the angular velocity about the axis of the projectile, which is always an axis of greater or least moment, should be so great, that if, by any disturbing effect of the resistance of the air or of want of perfect centreing in the projectile, so that the resultant pressure of the gases evolved from the powder does not pass exactly through the centre of gravity of the projectile, the instantaneous axis be shifted, the amount of shifting should be as slight as possible. Now, as the amount of angular velocity varies as the amount of "turn" in the rifling, it becomes of great importance to determine how much, and only how much turn is necessary, to insure stability of the rotation, as anything more than is necessary to insure this is injurious, from the strain imposed on the gun, as well as from the danger of "stripping" entailed on the bullet. Accordingly, the first chapter of 'Rifled Ordnance' being merely explanatory of the advantage of rifled over unrifled ordnance, the second is devoted to "the turn in rifling;" and here the author notices to expose an error entertained by "many persons," so he says—certainly not by many mathematicians—that the resistance of the air *assists* instead of retarding the angular motion of the shot! He then shows how the feathers of an arrow keep its course straight for a short distance, and in the vertical plane during the entire flight; and how different their action is from the projections on long projectiles for rifled guns; and afterwards proceeds to state that, "Since it is principally, if not entirely (he might have left out principally) from the resistance of the air that the necessity for rifling shot arises, the proper degree of rotation to be given to a shot will depend upon its form and weight, or rather density, and also on its size"—and proposes to apply these principles to the investigation of the proper turn for rifled guns; but we cannot follow him through the vast amount of detail and valuable but technical information to which he now introduces us. The Whitworth is we believe the favourite rifle at present, the bullet is three diameters long, and the "turn" is very great, necessitated as the author supposes by the increased resistance of the air, owing to its peculiar form, but, as we believe, by its greater tendency to turn over, owing to the centre of gravity not being forward enough. And indeed, immediately after describing the Whitworth bullet, the author informs us that, generally, "For shot of great length, a great turn is absolutely necessary;" and a

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little further on, "I found that shot of great length turned completely over on leaving the muzzle of the gun, although the turn was sufficient to keep a shot of less length perfectly straight." The author seems to have established that the greatest proportional length for projectiles consistent with stability of flight is about three diameters.

In the next chapter is considered the influence of size on the "turn," and here it is clearly shown how guns of large calibre require less turn than those of smaller calibre, on account of the resistance of the air being proportionately less on their projectiles. We must however protest against the author's assertion that "there is a very great diminution of the velocity from the resistance of the grooves" (besides or neglecting the friction), "whereby the motion of the shot is altered from a simple forward motion to a rotary one," the amount of pressure on the shot from the powder being supposed the same in the two cases of a smooth or rifled bore, the vis viva of the shot as it issues from the mouth of the piece will be the same; or if w be the angular velocity, m the mass of the ball, v the linear velocity, mk^2 moment of inertia about the axis. Then $mk^2w^2 + mv^2$ will be the vis viva of the rotating projectile, and mv_1^2 simply of the projectile from the smooth bore, so that $mv_1^2 = mk^2w^2 + mv^2$. Now the linear *velocity* of the surface of the projectile arising from rotation will rarely ever be more than 1-10th of the direct velocity, and if a be the radius of the projectile, aw will therefore be less than 1-10th of v, and k is less than a; much more will k^2w^2 be less therefore than 100th of v^2. So that v will be to v^1 in a ratio which lies between 1 and $\sqrt{\frac{99}{100}}$, and the difference between v and v^1 will be imperceptible from this cause.

In the next chapter on the projectile the author, as we have already stated, shows clearly the great advantage of having the centre of gravity well forward. A curious circumstance is here stated, "that rifled projectiles, even those of the most perfect construction, are invariably deflected in the direction of the turn of the grooves." The explanation of this fact, given by Prof. Magnus of Berlin, and quoted by our author, does not appear to us wholly satisfactory. Prof. Magnus assumes that the deflection of the vertex of the projectile, owing to the rotation of the instantaneous axis, occasioned by the downward resistance as the body descends in its flight, will always be in the direction of the turn of the groove, and it is easy to see that if the vertex be deflected in a given direction, for instance to the right, the resultant of the disturbances perpendicular to the plane of flight will tend to force the projectile in that direction also, that is to say, in the supposed instance to the right, and vice versâ; but as Mr. Thomas well observes, the professor has not examined what effect the position of the centre of gravity being very forward would have on this oblique motion of the shot, and it seems to us, that in the ordinary equations for determining the motion of the principal axis, terms and quantities which would be positive in one position of the centre of gravity relative to the surface of the projectile, might be negative in another; so that no general law of direction for the motion of the vertex can apply in all cases. Another most remarkable experimental fact, remarkable as illustrative of the small dependence there is to be placed on the theory of resistance, is that the sharp ends of solids of equal diameter suffered somewhat more resistance than their hemispherical ends; so at least the author assures us has been shown by the experiments of Dr. Hutton with the whirling machine. The author has also found that round-headed projectiles penetrated iron plates with greater facility than those of which the ends were pointed. We regret we have not space to describe the various shells invented by the author, and which appear to us to be admirably designed to insure stability of rotation and accuracy of flight; and indeed, in some experimental trials made with them these necessary qualities seem to have been perfectly attained. We shall not dwell on the next chapter, which treats of the form of the groove in rifled ordnance, except to observe that the author objects strongly, and we believe justly to the "increasing spiral" groove, to which indeed he attributes the occasional bursting of the Lancaster gun.

The chapter that follows on the comparison between rifled and smooth-bored guns is very important; the author shows, we think with much probability of truth, that smooth-bored guns of large calibre are frequently to be preferred to rifled ordnance. To begin with, rifled ordnance are always more or less complex in their construction, more likely to get out of order, and less likely to be well and quickly served in action, than smooth-bored guns; then the "ricochet" or rebound of a rifled projectile is not to be depended on, its angular rotation causing it to fly off at uncertain angles the moment it reaches the ground; and hence a very little reflection will shew us, that with smooth ordnance for all distances at which the flight can be depended on, we have a double chance of hitting an object as compared with rifled ordnance. We must remember too, that in almost all instances, what is desired is, not to hit a minute object at a very long distance, but a notable sized one at a moderate distance; thus in naval gunnery it is probable that at greater distances than a mile or a mile and a half no two ships would commence firing at each other, if at a greater distance it must be certainly with rifled ordnance; but then, owing to the great curvature of the line of flight for such extreme distances, it is very improbable that the exact angle would be at once found necessary to pitch the projectiles into the narrow line that the hull of even a first-rate would present as a mark when viewed so far off; so that but a small per-centage of shots fired would reach their mark: whereas for nearer distances, the apparent angular width of the hull would exceed the limit of probable error of deviation of heavy smooth-bored ordnance, and the double chance afforded by the ricochet would more than compensate for vertical errors of deviation; besides too as Mr. Thomas observes, "in naval engagements the rifled guns would have a great inferiority from the slowness with which only they could be served." The great advantage of rifled ordnance is that fortified positions might be more easily attacked by them; a small battery might be easily thrown up at a distance of three or four miles from a fortress, and shells pitched in somewhere amongst the works, with a very improbable chance on the part of the small battery of being at that distance hit in return. Mr. Thomas, without at all wishing to detract from the merits of the Armstrong gun as a beautiful and scientific projector of wonderful precision and enormous range, yet protests, on good grounds as it seems to us, against placing too much confidence in it as a weapon of actual warfare. Whatever advantages may be derived, and in many cases (some of which we have pointed out) those advantages are great, from the use of rifled ordnance, they would be better secured by the service of rifled guns less accurate and of smaller range, it may be, than Sir W. Armstrong's, but more easily constructed, more easily handled, and less easily deranged

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The Literary and Scientific Register and Almanack. The nineteenth edition, for 1860. By J. W. G. Gutch, M.R.C.S.L.—London: Kent and Co.

This cheap little cyclopedia for the pocket is such a summary of useful facts in all branches of science and art, that the man of scientific pursuits, the traveller, the merchant, and the mechanic, will each and all find it of the greatest utility as a book of daily reference.

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It is in the form of a small pocket book; and we are confident that our readers will form the same opinion as ourselves, that it is one of the most useful books of its kind published: to do this it is only necessary that they should procure a copy.

Ure's Dictionary of Arts, Manufactures, and Mines. New Edition. Edited by Robert Hunt, F.R.S., F.S.S.—London: Longman and Co.

A new edition of this work in monthly parts, of which three have appeared, claims the attention of every educated man, and from the well known character of Dr. Ure's works, requires but little to be said about it. Merely informing our readers that such a work is published, is we consider all that is required in this case, as it is a work of reference which they should all possess. We must add, that the present edition has been carefully revised to meet the advances made in inventive improvements, and new facts in science since the date of the last edition are introduced. We strongly recommend both the philosopher and the practical man to give Dr. Ure's book a place in his library.

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The Engineer's, Architect's, and Contractor's Pocket-Book for 1860. London: Lockwood and Co.

Another edition of this old acquaintance has just been issued, and fully merits in 1860 the estimation in which it has been held for many years. There is much new matter introduced, and the work has been carefully corrected up to the day of publication.

Relative to the Engineer's, Architect's, and Contractor's Pocket Book, comment on our part is unnecessary, from the fact of its being so well known, and the great age to which it has attained affording the best evidence that it is one of the most valuable books of its class. We can strongly commend it.

DESCRIPTION OF A MAGNETIC APPARATUS FOR ADDING ADHESIVE FORCE TO THE DRIVING WHEELS OF LOCOMOTIVES.*

By E. W. Serrell, C.E.

Almost all locomotives that have been built heretofore have an excess of steam power over their adhesion, and where this is not the case, the great weight that necessarily ensues, in some cases amounting to several tons beyond what is required for the proper strength of the parts, is not only an unnecessary load to carry every mile that the engine travels, but is so much dead weight producing impact, by which the track and bridges, and in fact the whole superstructure, is sooner or later destroyed.

The difficulties railway companies experience are manifold from the use of heavy engines. Not only the track is destroyed, and the bridges impaired, but the machinery itself more readily wears out its own parts by their great weight, and much more lubricating material is required; but railway managers find themselves forced between the two horns of a dilemma; for if they use light engines, there is not adhesion sufficient to draw the heavy loads necessary to a profitable business; while if heavy machinery is employed, it works its own destruction and that of the track on which it moves.

The destruction of superstructure due to locomotives of great weight has been carefully computed by the commissioners appointed by the states of New York and Massachusetts, and by several other eminent engineers, among whom may be mentioned Mr. William Raymond Lee, who has accomplished much to put this important question in its true light, as have also Mr. McAlpine and Mr. Charles B. Stuart; and others, and it has been found that the depreciation from this cause amounts to upwards of 26,000,000 dollars per annum in the United States alone.

Appreciating these difficulties, I went to work to see what could be done to remedy them, believing that science and experience combined could surely correct such grave errors as there must be in a system that resulted so destructively to its own best interests; and to this end I drew upon the intelligence of my friends in this country, Canada, England, France, and Germany. The replies without exception were, "You must increase the adhesion of the driving-wheels without adding weight to the engine." This was known to be necessary, but how to do it was the difficulty; and although some encouraged the hope, and others suggested the belief that it could be accomplished by various mechanical contrivances; nothing was proposed however that had not before been tried, and I was about to give up the investigation of the matter, and consider the case as one of those inevitable troubles that surround everything in some form, when, reading the researches of Dr. Henry, I was led to suppose that magnetism in some way might come to the rescue.

I was aware that attempts had been made in England to render the driving-wheels permanently magnetic, and that the engineers of the Chemins-de-fer du Nord, in France, had tried various forms of electro-magnetic helices; but all these attempts had proved failures.

My apparatus consists of a helical coil of copper wire or some other proper electrode placed transversely to the wheel and around the lower segment, in such manner that the wheel may revolve freely within it without at any point coming in contact with it. The helix is sustained in any convenient way to the frame of the engine, and consists in the experiments tried of about 300 turns of No. 8 copper wire, insulated with cotton and marine glue.

One peculiar feature of the helix is, that it is a segment struck from a radius of the diameter of the wheel, which was found to be necessary in order that the greatest magnetic effect might coincide with the point of contact between the wheel and rail.

My first battery consisted of sixteen Grove's cells, so modified that they would not stop by the motion of the engine; each cell had about 300 inches of zinc surface, and corresponding opposites of platinum and carbon, and the cells were connected in sets of eight for quantity—zinc to zinc, &c. My present batteries are a modification of Smee's and Chester's, which are found to be much more convenient.

By this arrangement, with the ordinary thickness of tire, the wheel is so magnetised as to enable the engine to exert its whole steam capacity. With two out of four drivers magnetised of the engine Anthracite, of the Fitchburg company, it was found that there was an increased adhesion of the wheels, and consequently of the traction of the engine, of over 75 per cent. The steam capacity of the engine being nearly double its adhesion without magnetism, enabled me to use the whole of the magnetic effect. I am indebted to Mr. O. D. Vormus, of Boston, for his very important aid in the experiments.

The engine Lebanon of the Central Railway of New Jersey, has two helices of 288 turns of No. 8 copper wire, on the front pair of the four driving-wheels, which are 4½ feet in diameter, and the battery is made in four cells, each having 20 square feet of zinc surface, and 18 feet of silvered lead coated with platinum, sulphuric acid, (HO. SO_3,) 1, water 12 is used to excite action, and the battery is connected for intensity. I am now preparing a magneto-electric machine to produce the electric current, hoping to dispense with the use of the battery altogether, and if successful the entire arrangement will be mechanical, and independent of chemical apparatus. Some of the engines of the Central Road of New Jersey, and the Erie Railroad of New York, have from three to five tons dead weight of cast-iron that can be taken off, and has been put on to give adhesion, and is otherwise useless.

This arrangement not only saves the great additional useless weight carried, and which is so detrimental to the superstructure, but enables the engine to ascend high grades. With a model, an ascent of a plane of 300 feet to the mile is readily made when the wheels are magnetised. The same model will not go up a grade of 80 feet to the mile without magnetism, because the wheels slip. The model is merely illustrative, and is capable of carrying about 200 pounds.

The following is the test applied to the Anthracite:—Engine chained up. Slipped wheels on clean track in good condition; circumstances every way favourable to traction, without magnetism, 50 lbs. steam to the inch. All the conditions alike and two wheels magnetised, slipped with 88 lb. of steam per square inch; slippery track, 19 lb. less steam to the inch without magnetism; same conditions with magnetism, required 35 lb. steam to the inch. The engine weighed 22 tons net, and the additional traction produced by the magnetism was equal to 17 tons of dead weight, but did not weigh anything. The Lebanon drew a coal train on a slippery rail equal to that which was being moved by another engine that weighed about fifteen tons more, and both starting together, the Lebanon kept out of the way of the other for some forty miles or more, when a leak occurring in the fire-box, sufficient steam could not be made to turn the wheels, and eight of the cars had to be taken off. The train had, however, previously passed the heaviest summits of the road.

* From the Journal of the Franklin Institute.

St. Paul's Churchyard.—We greatly regret to find that, notwithstanding the united remonstrances of the press, a huge warehouse, six stories in height, is being erected at the south-eastern corner of St. Paul's churchyard, by which the fine perspective view (as seen from the western end of new Cannon-street) of one of the finest temples in the world, will be completely destroyed. This act of vandalism on the part of the city authorities is much to be deplored. The Columbarium sort of well-hole at the western end of the site, is a very appropriate position on which to erect a statue to the great architect, Wren, in close proximity to his greatest work. This might be done by subscription, which no doubt would be liberally responded to.

A New Artificial Light.—An improved form of the lime light originally experimented upon by Captain Drummond, some years since, was shown by Sir Charles Bright, in the Exchange News'-room, Liverpool, on the 17th ult. A single jet of the improved lime light is estimated as equivalent to 40 Argand, or 80 fish-tail burners. Should the light be as economical and easy of manipulation as on this occasion, it will probably effect a considerable change in the lighting of lighthouses, public rooms, &c.

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SOME ACCOUNT OF LICHFIELD CATHEDRAL, AND OF THE RESTORATIONS IN PROGRESS.

(*With Engravings.*)

In the works and restorations contemplated and now going forward at Lichfield Cathedral, it is gratifying to find that here as well as in other cases of late, while the same are to follow and be subservient to the requirements of our present more simplified ritual, it is to be allowed that such can be attained without the sacrifice of the expression derived from the presence and proper position of features and arrangements sanctioned by ancient practice and founded upon all that is great and good in the purpose and teaching of our Church, but which it has been until comparatively lately—it should be said with sorrow—the fashion to care little for, if not wholly to discard. The restoration is, it is anticipated, to be "a model one;" and while recognising the necessity and providing for the greater usefulness of our cathedrals as places of public worship, will not neglect the proper consideration and retention of those main features in its old expression which, with relation to the objects they ought to subserve, are not less momentous or less to be desired now than they have ever been. With reference to the first point, it is proposed, we believe, as has been done in the case of Westminster Abbey and St. Paul's, to fit up the space under the great tower with seats, and to continue the same over a great portion if not the whole of the nave, to which, if we may judge from the late meeting of choirs, the pulpit, lectern, &c. will be removed; under which arrangement the choir will, we should suppose, be chiefly used for those attached by office to the cathedral, and perhaps for the clergy of the diocese, should it supply sufficient accommodation. As regards the second, it is intended, we understand, to place the altar table in its original place, and to re-erect the reredos which was taken down in the unfortunate changes made some 60 years ago. This will permit again the use of the lady-choir for the early service appointed by the statutes to be daily said there. It ought to be generally known that the statutes distinctly provide for a service for the convenience of labouring people, servants, artizans, and those engaged in trade ("non modo servi, sed etiam minorum gentium artifices et mercatores," are the words of the statute) at an early hour—about seven in the morning—to be said, and not sung, in the lady-choir; but that part of the sacred edifice having been injudiciously thrown in to form part of the great choir, the important and truly English service ordered so considerately to be there performed has been almost necessarily omitted since the change. The communion table and reredos will be placed, as formerly, at the second pillar westward from the lady-chapel; and near to it, some yards further westward on the south side, will be the bishop's throne, between which and the gates opening into the choir, we are informed, will be the stalls, eighteen on each side, besides the substalls; the six middle stalls on each side with their substalls being set apart for the vicars choral and the choristers. The design for the choir-screen and gates, of which, by the kind permission of the dean and chapter we are enabled to give illustrations, is of open metal-work, and very elegant, sufficient to preserve the character of a choir, and yet open enough to permit a full participation in the service by the worshippers about and outside of it. One advantage of this arrangement will be that persons will be relieved from the undesirable necessity of facing each other in service, as was the case in the old choir; the annoyance of which would be still more felt in the new fitting up which is proposed, inasmuch as the stalls will now it appears be nearer to each other, and not recessed. The reason for not recessing them again is stated to be the projection of the pillars of the great tower at the entrance to the choir. To recess the new stalls would, it is alleged, hide the officiating ministers from the view of the congregation seated in the tower and nave.

The narrowness of Lichfield Cathedral creates a great difficulty both in the arrangements of the choir and in the placing of the organ. How the latter difficulty, namely, the placing of the organ, will be got over, we cannot say. Had the side aisles been higher and broader, a place might readily have been found here for the organ. The beautiful double tier of arches in the great tower, now hidden from view by the comparatively modern insertion of a stone roof will, it is hoped, be taken away, and a new roof put in at the old place high up in the tower, so as to form a lantern. The place where the old roof formerly was is sufficiently indicated by the remains of the old corbels. When the reredos is restored, and the lady-chapel thus again made distinct, we may trust that a screen will be erected where one formerly was, namely, at the entrance to the lady-chapel. This last mentioned screen followed doubtless the style of those to be seen in apsidal chapels in many French cathedrals. Judging from the account given of it in Shaw's 'Staffordshire,' this was one of the most elaborate portions of the church, the work being connected in some manner with the shrine of St. Chad, which shrine stood between the reredos and the lady-chapel screen. The places in the side walls of the choir where this rich screen was inserted may now be seen as the restorations are proceeding. Those who are familiar with the history of the church will recollect that the altar of St. Chad was where Chantrey's celebrated monument now is, that is, at the east end of the south aisle of the choir; and the altar of St. Peter on the opposite side, that is, the east end of the north aisle of the choir; that of St. Thomas in the side chapel of the south transept; and that of St. Stephen in the chapel in which is now placed a monument of Bishop Ryder. In addition to these there were other chapels, about twenty chantries being mentioned in Harwood's 'History of Lichfield.' A piscina is still to be seen in one of the rooms over the ancient sacristy now used as the Consistory Court of the diocese. The late excavations which have been made in the warming of the church by hot air and hot water, have brought to light some interesting facts relating to the former structures which have existed where the cathedral now stands. The foundations of a church, less in breadth than the present church by the thickness of the walls on each side, have been found, terminating towards the east in an apse, about midway of the present choir, that is, at the fourth pillar westward, reckoning from the lady-chapel entrance. In the extreme east part of this apse was discovered a round hollow space in the wall, 6 feet in diameter. These foundations belonged perhaps to the church which Bishop Jaruman is said to have built A.D. 667, and into which Bishop Hedda, in A.D. 700, translated St. Chad's bones, taken from the neighbouring church of Stowe. Of the history of the church said to have been erected by Bishop Jaruman little or nothing is known, except that it suffered greatly from the Danes. About A.D. 1130 Bishop Clinton restored and enlarged, if he did not entirely re-build, the cathedral of Lichfield. He built a bishop's palace at the north-west angle of the close, and added much to the wealth and dignity of his cathedral church. In his time, or soon after, the church was extended farther eastward than the church ascribed to Jaruman—Clinton's church, namely, was extended to the place where the altar table will now be restored to, that is, the second pillar west from the entrance to the lady-choir. It is worth remark, that as in the former church, so also in this of which we are now speaking, there was a round hollow space in the east wall of about 6 feet diameter. Many foreign churches have tombs of eminent persons in the same relative position, and some of them not unlike in size, though many of them also larger (see Fergusson's 'Handbook of Architecture,' vol. ii., p. 483.) Under the place of the grand altar just mentioned was lately found a basin of stone at the distance of about 3 feet below the present floor, containing molten metal mingled with earth. That St. Chad's shrine was always near the chief altar cannot well be doubted. There is a well known passage in 'Bede's Ecclesiastical History,' bk. iv., which may be here referred to:—"Ceadda died on the 6th of the Nones of March, March 2, A.D. 672, and was buried near St. Mary's Church, but afterwards when the church of the most holy prince of the Apostle Peter was built, there his bones were translated into it. The place of his sepulchre is a wooden monument made like a little house covered, having a hole in the wall through which those that go thither for devotion usually put in their hand and take out some of the dust, which they put into water and give to sick cattle or men to taste," &c.

When Bishop Langton in 1296 still further lengthened the choir and commenced the lady-chapel, the place of the grand altar was not disturbed. A screen or reredos was placed instead of the former east end, and it was then that the shrine of St. Chad was placed between the reredos and the lady-chapel. The additions which Langton made to the church were very considerable. He may almost be said to have rebuilt it, for the most part, as it now is, leaving only some parts of the previous church about the great tower, the transepts, and the sacristy standing. This will account for the first three pillars in the choir (entering from the west) being older in style than the rest. To harmonise these however with the new arches eastward, as well as to give increased richness to the choir, six canopied figures, three on each

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side, were placed between the pillars just mentioned. These are now being restored. The former figures, canopies and pedestals, were destroyed at the time before alluded to, namely, 60 or 70 years ago, when also the cinquefoils between the arches throughout the choir were chiselled off with the same exquisitely barbarous taste, and at the same time were defaced and almost destroyed the mouldings of the arches themselves and the capitals of the pillars, to give place to imitations of Gothic in plaster. This sad work has lately of course had to be undone, and the arches, etc., restored in stone, every effort being evidently used to restore the portions disfigured to what they were at first. The stone roof of the church dates from the time of Bishop Blythe, who lived a little before the Reformation. It is in course of being rescued from the whitewash which has long hidden much of its beauty. In clearing it, traces of the old colouring and gilding have been very distinctly brought out, and will now to some extent at least be restored. In certain of the bosses in the middle rib of the choir roof are drilled holes, probably for the suspending of lights or other pendants—as for example, before the grand altar, before the altar of the lady-chapel, and over St. Chad's shrine. There is no crypt under the church, but on the south side of the lady-chapel are three small chantries or cells, interesting and deserving of restoration, their dilapidated appearance being painfully conspicuous on approaching the close from Dam-street. In the restoration which was made of the great tower after its fall, some little deviation was allowed from the old proportions, the tower part being scarcely so high, and the spire part a little higher than it used to be.

The parts of the building and close which require explanations as to the use formerly made of them, are the room over the chapter-house, now used as a library, together with the chamber formerly opening into it, but now used as a lumber room, the thirteen recessed and highly enriched niches, or rather arches, in the passage from the north aisle of the choir to the chapter-house with the openings formerly behind them, but now blocked up, and the range of arches on the outside of the south transept—on its west side—to which points of inquiry must be added the question of the cloisters given by Bishop Langton (see Harwood, page 10), of which no trace can now be seen. They were doubtless on the south side of the church, and their exact position may be defined with a high degree of probability. Direct information however, would be of great value in an archæological point of view.

The restoration of the outside of the cathedral, whenever attempted, will include the substitution of stone for the plaster in the west front, the figures being again placed in the vacant niches, and the statue of King Charles the Second, which now occupies the chief niche, replaced by that of St. Chad or some other pious founder. It is a great pity that the height of the north-west spire was altered, for the alteration destroyed one more proof of the symbolic system said to have been observed in the construction of Lichfield Cathedral, whilst at the same time it detracted from the beauty of the spire itself. On this part of the inquiry about Lichfield Cathedral just hinted at—namely, its symbolism—as well as on other points, the series of papers which some time ago appeared in the 'Lichfield Telegraph,' are well entitled to the consideration of the curious in such matters. The beautiful centre porch of the west front would require careful restoration if touched at all. When it was meddled with some years ago two at least of the canopies of the figures, as well as the figures themselves, were taken quite away, and plaster canopies and pedestals substituted without figures. The old canopies are in a garden near Lichfield, and are exquisite pieces of work. No restoration of the exterior could take place without pulling down and rebuilding the large masses of bare stones placed as buttresses at the corners of the south transept and one on its western side. The remarks these erections called forth even at the time they were made are worthy of being referred to. The extract is from 'The Gentleman's Magazine,' Nov. 1795, and signed "Viator," page 924: "The observation in your magazine for September, page 785, on the reformed state of Lichfield Cathedral (1794) is a very just one—'that it is all seeing and no hearing.' The first part of this remark would be as true as the second if there were anything to be seen in this reformed style of Gothic architecture. But the fact is, and a melancholy fact it is, that by it Milton's long-drawn aisle is transferred to the choir, till it is wire-drawn and made as long, if not longer, than the nave. Every method of confusion is introduced; the periods of Gothic architecture are cruelly confounded; the monuments and even the ashes of the dead removed; and instead of the fine masses of colour of the ancient glass-stainers, with their blended tints, some blaze of one or two colours predominates, and all the lights on either hand of it are put out to set off a single window." (The glass here complained of was splendidly replaced by the late Dean Woodhouse, as we now have it.) "Viator" continues—"This I have actually seen at Lichfield; and I have farther seen the south transept buttressed up at the south end with two such masses of stone work as would disgrace the clumsiest country mason."

Among the buildings in the close the loss of which is to be regretted, may be noticed the large hall belonging to the magnificent palace built by Bishop Langton on the site of the present palace. The restoration of such a hall would be valuable for ordination examinations, transacting diocesan business, and for other church assemblages. The college for the choristers is another loss, especially the hall formerly provided there for the practice of singing. The gateway of this college is given in Shaw's 'Staffordshire.' It stood at the north-west corner of the close. The recovery, too, of the Vicar's Hall might tend to bring back something of the collegiate character and worthy position of that ancient corporation.

COLOUR AS APPLIED TO ECCLESIASTICAL DECORATION.

At the meeting of the Liverpool Architectural Society on the 12th ult., Mr. G. A. Audley read a paper on the above subject.

There was, he said, at the present time a great feeling of prejudice against the introduction of painted ornaments into our churches. No sound reason could however be given for this prejudice. That it partakes of Roman Catholicism, and that it is expensive, were two of the arguments most commonly advanced against it. The former amongst persons of sense could make no way; and as regarded the latter, he was of opinion, that were the art liberally encouraged, its present expense would be reduced to one half, while its character would of necessity, by education, be improved. If inspiration in this beautiful and truly artistic and architectural art were sought at the fountain head, namely, from the remains spared to us from the crushing wheels and blighting breath of time, how easy the task became: they might turn over the pages of those vellum wonders, finding more than enough to lead them on their way—more than enough, if they were alone to copy, to decorate—and that with a feeling and spirit they could scarce hope to attain—all the sacred buildings in our land. They must not however copy verbatim the works of the middle ages; they were now differently situated as regarded religion and manners, and corresponding changes must be made in most works of Gothic art. Nor was it necessary to introduce into our Protestant churches those features which savoured of Roman Catholicism; taste and good sense must here be the safeguard, and all must be tempered to suit the building under treatment.

He next proceeded to make a few remarks on the modern application of the art, dividing them into separate heads—as having reference to the several portions of the Gothic interior, premising that circumstances altered cases, and that at all times his remarks would not apply. He first touched upon wall decorations, remarking that walls of stone or plaster might be decorated in many ways with great effectiveness, and suitable decorative mediums might be applied to nearly all open or bare spaces. In the decoration of large spandrils, which were so common in Gothic buildings, the artist must introduce some rich and bold centre-piece, such as a geometric Gothic figure charged with a symbol, a monogram, or some suitable heraldic enrichment or emblazon. The colour of this leading design must be superior, though in harmony with, the decoration surrounding it. There were several ways of completing the composition with the centre ornament he had alluded to—firstly, by decorative scroll-work, similar in character to that of the twelfth and thirteenth centuries, starting from behind it and sweeping into the form of the spandril, richly coloured in flat, hard-edged shading tints; soft graduated colours in Gothic ornament must be avoided, as having no effect at a distance. Secondly, the wall surrounding the leading ornament may be covered by a diaper or some neat geometrical design in gold and colours upon the natural stone, or upon some harmonious groundwork. Thirdly, the centre-piece may be painted alone upon the stone, or upon a neutral or light positive tinted ground, having a border around the mould-

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ings of the arches, &c. inclosing the space. Fourthly, instead of a geometric outlined centre-piece, a Gothic scroll or ribbon creased to suit the shape of the spandril may be used, having a text or motto upon it in black letter. When decoration was not carried to the extent he had described, a rich ribbon alone might be creased in an artistic manner around the upper side of the hood-moulds.

When the space above the chancel arch was to be decorated, the same suggestions might be applied as were in the aisle-arch spandrils, although owing to its shape (that of an arch above and below) three principal ornaments might be used, a major one being placed at the apex of the hood-mould. Pictorial decoration perhaps would be most suitable here,—it was a position favourable to a fine composition, and the several decorative figures throughout the church might here be brought together to form one gorgeous whole. In the chancel or choir the only difference in the wall decoration might consist in its being richer in colour or more elaborate in design. Diapering and powdering might be applied to those flat or plain surfaces of wall which were to be enriched, but had no great prominence in the general design of the interior.

Gothic mouldings from the earliest ages seemed to have been richly decorated; they were very suitable for receiving the highest play of colour, assisted by the natural effect of light and shade. The mouldings in a Gothic interior occupied a very prominent and influential position in the list of decorations as they were naturally, but much more so if richly coloured and gilded. He made various suggestions for the decoration of mouldings, as also of shafts, and next alluded to groined roofs, which presented favourable surfaces for elaborate decoration, and, he said, of all portions of a Gothic interior they were most suited to receive it. The canopy effect of the vault in itself, spanned and laced with richly moulded ribs, seemed, unaided by colour, fully to satisfy the eye; while, when blazing with decorative splendours, its effect was sublime in the extreme.

The decoration of groins was somewhat similar in its principles to that of spandrils. The centre feature, with attendant ornaments, should be introduced in each compartment of the vault, if it were simply ribbed, as in the Norman and Early English examples; but when cross-ribbed in the complex manner of the Late Decorated or Perpendicular, designs of a smaller and simpler character must be introduced, such as emblazoned shields with ribbons, small scrollwork compositions, &c., the ornament of course agreeing with the style or period it was applied to. Under the head of general ornaments might be included all the representations of architectural ornaments, such as canopies, capitals, buttresses and mouldings, and the very numerous enrichments distributed in a Gothic interior. All these must be treated in a truly conventional manner: conventionalism was one of the greatest peculiarities or characteristics of Gothic decoration, and might be looked upon as being its greatest charm and recommendation.

Having described the various methods of decorating oakwork and the different modes of carving, he said in conclusion, "I trust the few hints I have just offered, though almost worthless in themselves, may have the effect of inducing some to fully study the truly beautiful art with which they are connected. The world is awakening from a sleep of many years, and is beginning to appreciate the beauties found everywhere scattered amongst the works of the past. More may yet be found—the mine is not yet robbed of all its ore; there are other veins, if we know but which way they lie; the shaft is not deep enough, but it will be deeper yet. Who will be the successful miner?"

HASTE'S SAFETY VALVE FOR STEAM BOILERS.*

By William Naylor.

(*With an Engraving.*)

In the explosions of steam boilers, which are still of frequent occurrence, the cause of the explosion too often remains a mystery, and is not satisfactorily ascertained so as to afford a guide towards guarding against the recurrence of such accidents. The author has a strong impression that in several cases of boiler explosions the cause has been simply over-pressure beyond the calculated or known pressure in the boiler; and that the over-pressure was caused by the safety-valve in use not carrying away the steam as fast as it was generated. In three cases that came under his particular observation, the firing was going on as if the engines were in full work; whereas neither were the engines at work, nor was any feed water being pumped into the boiler for some 10 or 15 minutes before the explosions took place: consequently the boilers were generating as much steam as would have supplied the engines at work; and in addition the amount of fuel required for heating the feed water from the temperature at which it entered was spent also in generating steam, so that more steam had to pass away through the safety-valve than was necessary to work the engines at their full power.

A safety-valve loaded to a certain pressure per square inch, so that whenever that pressure is attained in the boiler the least addition to it will cause the steam to begin to escape, is not by any means a guarantee that the steam will be carried away as fast as it is generated, and no surplus pressure allowed to accumulate in the boiler above that at which the valve is loaded to blow off; and it appears from experience that ordinary safety-valves do not effect this object, as further shown by experiments afterwards described. At the time when 50 lb. per square inch was the working pressure in locomotive engines, say 25 years ago, the practice was to have one valve loaded by a lever and spring balance to 50 lb. per square inch, and a second valve similarly loaded up to 60 lb. per square inch. The author has frequently noticed that when the one at 50 lb. was blowing off strongly the one at 60 lb. would begin to blow off, and often both valves would blow off very strongly; proving that there must be a surplus pressure of at least 10 lb. per square inch above that at which one valve was intended to carry the steam away as fast as it was generated. Such valves loaded by levers and spring balances are very generally used on boilers supplying moderately high pressure steam to stationary engines, and also on locomotive engines; but they are defective under the most favourable circumstances, if required to pass any great amount of steam; and they are open to the objection that they may be overloaded by weights being added on the lever. In this respect there are a few valuable exceptions, but only a very few, in use at the present time.

The want of a sufficient amount of water in the boiler is also no doubt the chief cause of many explosions of steam engine boilers, more especially those attached to stationary engines. For by the water getting below the top of any portion of the heating surface which is acted upon by the fire, that portion soon becomes overheated and reduced in strength, until it is unable to bear the pressure of the steam upon it; under these circumstances something must give way, and the result must be an explosion.

It is therefore desirable that an arrangemant of safety-valve should be adopted which will accomplish the three following objects:—to carry off the steam as fast as it is generated above the pressure the boiler is intended to work at; to be entirely out of the reach or control of any one to tamper with or overload it; and to be so arranged that, in the event of the water getting low in the boiler, the valve shall blow off steam and avoid the possibility of any explosion or injury beyond the burning of the plates if more water be not supplied.

The plan of safety-valve forming the subject of the present paper, which is the invention of Mr. J. Haste of Leeds, has proved highly successful in accomplishing these objects. The arrangement is represented in Fig. 1, Plate 5, showing a section of the valve and its connection with the boiler.

The valve A, by which the steam escapes into the atmosphere when the limit of pressure is exceeded, is made with two seats, the upper one being 3 inches diameter and the lower 3¼ inches diameter, the difference being 1·23 square inch area. The steam presses on both ends of the valve, passing up through the middle of it, so that when the valve is open the steam escapes at both ends into the casing surrounding the valve and thence into the atmosphere. This valve is not moved off its seats by the steam acting upon the difference of area of the two ends, but is forced open by steam acting upon the piston B, the rod of which presses on the valve A. The small safety-valve C, by which the limit of pressure of the steam is fixed, is loaded by a dead weight D, inclosed in a chamber and guided at the top by a small piston E, working in a cylinder of the same area as the valve C below. Whenever the pressure of steam in the boiler exceeds that to which the small valve C is loaded, it will be raised from its seat; and the steam escaping will accumulate in pressure upon the top of the piston B. The area of this piston is 7 square inches, or nearly

* Paper read at the Institution of Mechanical Engineers.

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six times the difference of the area of the valve seats A. Taking the pressure of steam in the boiler at 35 lb. per square inch, there is a force of 42 lb. tending to keep the escape valve A closed, equivalent to a pressure of 6 lb. per square inch on the under side of the piston B; so that when the pressure above the piston has reached 6 lb. per square inch, any increase of pressure must open the escape valve A: and if there be a pressure of 35 lb. per square inch upon the piston B, this gives a force of 245 lb. tending to open the escape valve against a resistance of 42 lb., leaving an effective force of more than 200 lb. to open the escape valve A. Upon the area of opening afforded by the valve will depend the efficiency of its action in preventing a surplus pressure of steam from accumulating in the boiler.

One of these safety valves, of the construction shown in Plate 5, is attached to a boiler at the works of Messrs. Bray and Waddington, of Leeds. The boiler is 24 ft. 3 in. long, and 6 ft. 6 in. diameter, with two flues of 2 ft. 6 in. diameter, and firebars 6 feet long in the flues, giving an area of firegrate of 30 square feet: it supplies steam to three non-condensing engines of 34 total horse-power, working at 35 lbs. per square inch pressure. In order to ascertain by experiment the action of the valve, a pressure gauge was attached to the top of the chamber D, in addition to one placed on the boiler: the small valve C was loaded to 35 lbs. per square inch. After many trials with the whole of the steam that the boiler could generate passing through the escape valve A, the pressure did not exceed 37 lbs. per square inch in the boiler, or a surplus pressure of 2 lbs. per inch. The valve A was then purposely prevented from blowing off until there was a surplus pressure of 3 lbs. per square inch upon the piston B as well as in the boiler, as shown by the two pressure gauges; the valve A was then forced full open by the pressure of steam, and it was found that the pressure in the boiler was reduced to 35 pounds per square inch in a few minutes.

In order to ascertain the real value of this safety valve as compared with the ordinary valve, the following experiments have been tried by the writer, in which every care was taken to prevent error in the result; the fires were clean and free from clinker, the fuel good coal and well ignited; none of the engines were at work, nor was there any outlet for steam to escape except those intentionally allowed; nor was any feed water pumped into the boiler during the time of experiment.

The first object in the trials was to ascertain how fast the pressure of steam could be raised to the point of blowing off; say from 5 lbs. up to 35 lbs. per square inch. This time was found to be 13 minutes, making 2·3 lbs. rise of pressure per minute.

The next object was to see how the pressure would be affected by an opening of 1 square inch area being allowed for the steam to escape through; and when the pressure had been raised to 35 lbs. per square inch, a slide valve was opened turning the steam into a 4-inch branch pipe, upon which was bolted a plate with a hole of 1 square inch area, through which the steam escaped freely into the atmosphere. It was then found that the pressure in the boiler oscillated between 35 lbs. and 43 lbs. per square inch; and at the end of 45 minutes the maximum of 43 lbs. pressure was attained. The slide valve was then shut and the steam turned on so as to pass out by the new safety valve, shown in Fig 1, the pressure gauge on the boiler and that on the chamber D both showed 43 lbs. per inch, and the escape valve A was instantly forced full open and down upon the studs below it. The pressure in the boiler was then reduced by the valve from 43 lbs. to 38 lbs. in the first 5 minutes, and finally to the ordinary working pressure of 35 lbs. in 15 minutes. The firing for the whole hour had been much forced, and was much above that necessary to drive the engines in their ordinary work. On observing the water level it was found that in the hour 57·5 cubic feet of water had been evaporated into steam, which would be sufficient to have supplied a 60-horse power engine. Hence with this generation of steam a hole of 1 square inch area was sufficient to keep the pressure down to 43 lbs. per square inch during 45 minutes; while with the new safety-valve the pressure was reduced to 35 lbs. in 15 minutes.

An experiment was then tried to ascertain how far an ordinary safety-valve of 3¾ inches diameter would keep the pressure from accumulating in the boiler above that at which it was set to blow off. The valve was loaded by a lever and spring balance, and 1 lb. on the balance was equal to 1 lb. per square inch on the valve. When the pressure gauge upon the boiler showed 43 lbs. per square inch and the spring balance was set at 43 lbs., there was a very slight blowing off at the valve, showing that the pressure gauge and spring balance agreed. The spring balance was then slacked back to 30 lbs., allowing the steam to blow off freely; in 5 minutes the pressure gauge on the boiler showed 46 lbs., in another 5 minutes 46½ lbs., and in 5 minutes more 46 lbs. Thus for 15 minutes, with a valve loaded to only 30 lbs. per square inch above the atmosphere, the actual pressure in the boiler was 46 lbs., being a surplus of 16 lbs. above the pressure that the valve was adjusted to blow off at, or 35 per cent. of surplus pressure. In the previous experiment it has been seen that an opening of 1 square inch area carried off the steam as fast as it was generated, without allowing the pressure to exceed 43 lbs. per square inch. But in the present case, with a valve of 3¾ inches diameter or 11 square inches area, in order to give an opening of 1 square inch area round the circumference, ·085 inch width of opening would be required, or ·122 inch vertical lift of the valve, the circumference being 11·78 inches, and the face of the valve being inclined at an angle of 45 degrees. This lift of the valve would extend the spring balance 1·34 inch, the leverage being 3¼ and 35¾ inches; and as the scale of the spring balance gave 12 lbs. for each inch of extension, an excess of pressure of 16 lbs. per square inch would be caused by this lifting of the valve in blowing off, which would give an area of opening of only one square inch for the steam to escape. This result agrees with the observed surplus pressure of 16 lbs. per square inch. In the ordinary safety-valves there is also frequently a cause of overpressure, in consequence of the valve being inclosed in a chamber from which the steam escapes through a pipe into the atmosphere; if the steam is roaring through this pipe there must be some pressure of steam in the chamber to occasion that roar, thus causing an increased pressure on the valve above the limit to which it is intended to be loaded.

The other source of explosion—the want of water in the boiler—is provided against in this safety-valve by the float F, which on falling below its proper level opens the escape valve A, and lets the steam escape from the boiler to the atmosphere, regardless of its pressure. The author has found by repeated trial and the results of regular working that, whenever the water gets below the working level in the boiler, the float descending with it opens the escape valve, allowing the full opening for the discharge of the steam, and the valve cannot be closed again by any other means than the proper supply of water, raising the float to its original level. In experimenting upon the boiler, when the escape valve was opened by the float to the full extent the pressure of steam was reduced at the rate of 2 lbs. per square inch per minute. The loud noise of the steam escaping could not fail of itself to call attention: but even if not attended to, the only result would be that the steam would be all let out of the boiler, and the engine stopped, all danger of accident being avoided.

THE PHOTOGRAPHIC SOCIETY'S EXHIBITION.

The exhibition of this society, now open in Pall-mall East, although it does not prove any great advances in the art (beyond the important process of fixing in carbon instead of nitrate of silver) is of average merit. It consists of 586 frames, some of which contain several examples. Copies of oil paintings are not generally successful, and the present collection confirms that opinion. The landscapes of Maxwell Lyte are excellent. The architectural studies of Roger Fenton and Bisson Frères are quite equal to their former merit. The series of copies from celebrated drawings taken by Mr. Thurston Thompson for the Department of Science and Art, South Kensington Museum, afford a striking example of the great value of photography in art education. In portraits Mr. Herbert Watkins is favourably conspicuous.

Among the curiosities of the exhibition are some excellent copies of music by Mr. M. P. Rippingham; also M. Joubert's phototype specimens; and some photographs taken by artificial light produced by Moulé's patent apparatus for burning pyrotechnic compositions, and exhibited by M. Garnier.

A more advantageous display, and a more satisfactory examination of the works exhibited could have been secured, had the society a larger amount of space at its disposal, but all has been done in this respect by the officers that could be under the circumstances.

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GLEANINGS FROM WESTMINSTER ABBEY.*

By G. G. Scott.

I have given my paper this title with the intention of expressing that it is intended in no degree as an historical, architectural, or antiquarian treatise on this magnificent building, but simply as a casual notice of objects or of subjects connected with it which have occurred to me as being less known or less noticed generally than they deserve to be. I had long ago thought of writing such a paper, but during the interval my intention has been in a great degree forestalled, both by my having had occasion myself at several times to call attention to many of the points I have now to notice, and further by the interesting discussion introduced some years back at this Institute by Professor Donaldson, on the subject of the shrine of Edward the Confessor.

Though I use the word "gleanings," I do not mean to imply that the harvest is over; on the contrary, the antiquarian and documentary part of the subject is, I am convinced, not only unexhausted, but scarcely entered upon. We really know next to nothing of the actual history of this the most nationally interesting of English churches. The information given us in the published histories is meagre in the extreme, while the public records and the archives preserved in the church seem as yet to have been only very partially searched for information as to its structural history. I earnestly wish that some of our learned antiquaries would take this interesting task in hand. It needs long and laborious research, but I feel sure that the labour would be richly rewarded. I will here add, that since I wrote the foregoing sentence, much has been done towards this object by Mr. Burtt, of the Record Office, which I shall have to notice hereafter.

All we know of the earliest history of the fabric is, that there existed a church here in the days of King Offa, and that this (or a successor of it) was rebuilt, and the abbey refounded, by Edward the Confessor. One of the first thoughts which occur to us in considering the history of our Abbey is, then, the question as to what kind of church was that which preceded the present structure, and which we know to have been erected by this sainted monarch. As, for example, what was its size and form? Was it on the small scale which appears to have been common among Saxon buildings, or of the gigantic dimensions adopted by the Normans? And again, was its architecture more on the Saxon or on the Norman type?

William of Malmsbury, writing in the following century, speaks of it as "that church which he the first in England had erected in that mode of composition which now nearly all emulate in its costly expenditure;" or, in other words, it was the earliest Norman church.

Matthew Paris, in the thirteenth century, merely adapts the same statement to his own times, saying that the Confessor "was buried in the church which he had constructed in that mode of composition from which many of those afterwards constructing churches, taking example, had emulated in its costly expenditure;" evidently considering its style the same as that of the Norman churches with which he was surrounded.

Sir Christopher Wren gives us, as he says from an ancient manuscript, the following particulars:—"The principal area or nave of the church, being raised high and vaulted with square and uniform ribs, is turned circular to the east; this on each side is strongly fortified with a double vaulting of the aisles in two stories, with their pillars and arches: the cross building, contrived to contain the choir in the middle, and, the better to support the lofty tower, rose with a plainer and lower vaulting, which tower, then spreading with artificial winding stairs, was continued with plain walls to its timber roof, which was well covered with lead."

From the above one would by no means infer that the church was of small dimensions, and I am very much disposed to think that it may have been nearly, or quite, as large in its elementary scale as the present structure. Edward the Confessor having spent so much of his early life in Normandy, it is unlikely that he should be content with the dimensions of a Saxon church; indeed, had he been so, he had one to his hand without building a new one; and as he was greatly enlarging the monastic establishment, it seems probable that in rebuilding the abbey church he would adopt the scale which was becoming common in Normandy. Harold, we have every reason to believe, did the same in building his church at Waltham; for whatever may be the merits of the disputed question as to whether any part of his work yet remains, there can be no doubt that his choir, at least for a time, co-existed with the present nave, and agreed with it in elementary scale. Again, we have no reason to believe that the choir of Westminster Abbey was rebuilt between the days of Edward the Confessor and those of Henry III., which would have been inevitably the case had its scale been diminutive; and, if it did exist through that interval, we have full proof that it was as long as the present eastern arm of the church; for the present position of the transept we know to be identical with that of the Confessor's church, from the fact of the remains of his dormitory abutting against it in the usual manner; while the eastward extent of the old church is defined almost with certainty by the fact that the lady-chapel was erected against it in the early days of Henry III., some years before he commenced rebuilding the church itself. The dimensions of the ancient nave are less easy of conjecture. The width, I think it probable, would have agreed with the existing one; and if the Confessor adopted, as I imagine, the usual scale of the great churches of the Normans, there is no reason to suppose it to have been much shorter than at present,—an opinion which is to a certain extent corroborated by the size of the cloister court, the north and east sides of which would have been defined by the external walls of the nave and the dormitory, and its southern limits by the refectory, in which there exist early remnants sufficient to show that it occupies its original site. The completion of the square thus marked out carries us to within three bays of the western towers; and as cloisters rarely reach the end of a nave, it leaves it as a probable inference that the old nave did not fall far short of the length of that now existing.

At St. Alban's and Winchester, which were erected within the same century, the elementary scale, or width from centre to centre of the piers, is about the same, the length of nave considerably in excess, and the original length of the Norman choir also greater. The structural choir or eastern arm at Westminster is, in fact, so short, as to preclude the idea of its having been rebuilt during the later Norman period, being less than that of many early Norman choirs.

We now come, however, to surer ground. I mean the portions of the Confessor's work which still exist. These consist of the substructure of the dormitory, forming a long range of building running southwards from and in a line with the south transept, and passing under the library and the great school-room, which now occupy the position of the ancient dormitory.

The substructure is vaulted in two spans, and is divided longitudinally by a range of massive round columns, the whole being seven and a half bays or about 110 feet in length from the vestibule of the chapter-house to the cross passage now leading into the little cloister, and formerly to the infirmary. This range was probably, in the first instance, continuous and open, like that at Fountains Abbey, but was very early divided into separate compartments, as I shall presently show. It is so seldom that we find constructive columns remaining in this country of a date earlier than the Norman Conquest, that it is an object of some interest to see what form they exhibit, though I admit that, date alone excepted, this can hardly be called a Saxon work, whilst its unimportant purpose forbids us to take it as a fair example of any style. There are only one or two of these columns which retain their pristine form, the others having been altered at subsequent periods.

These consist of a cylindrical shaft, 3 ft. 6 in. in diameter, and 3 ft. 4 or 5 in. high. The capitals have a vast unmoulded abacus, 7 or 8 inches deep, supported by a moulding, if such it may be called, consisting of nothing but a frustum of an inverted cone, the most pristine form almost to which a capital could be reduced,—thoroughly efficient, but with the least possible amount of workmanship, not unlike what we may imagine may have been the first type of the Doric capital, and but one step removed from its apparent prototype among the tombs at Beni Hassan.

We must not, however, for a moment suppose that this rudely pristine form was that usual at the period, except in rough and unimportant situations. We know that in the contemporary work at Waltham, the capitals were enriched with ornaments of brass, and that much earlier Saxon columns had enriched capitals. We must simply view it as a specimen of the honest simplicity with which they treated the less important portions of their structures. It is, in fact, only one step more plain than the capitals in the crypt at Winchester, which was constructed some twenty years later. The bases very closely resembled the capi-

* Paper read at the Royal Institute of British Architects.

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tals, but have, like them, generally been altered from their original form. These columns carried plain groining, with square transverse ribs, partly constructed of tufa.

It is somewhat curious and interesting, that during the Norman period the majority of the capitals have been altered and enriched in various ways. Being within reach, their massive plainness seems to have tempted the monks to try experiments upon them, and we accordingly find the original block cut into a great variety of forms, some of them of considerable richness. The state of the capitals shows that the building was already subdivided, as the alterations are often totally different on the two sides of the capital, leaving a narrow intervening frustum of the original, representing the thickness of the partition. Some are roughly chopped into a form, preparatory to the enriching process, which has not been completed. The bases were also altered, and in some instances at least the floor so much lowered that the lower part of the columns had to be cased with new stone.

The first bay of this early work adjoins the outer vestibule of the chapter-house, and is imperfect, having been shortened by the later buildings which here abut against it. The capital of the column here visible is entirely altered to a round and slightly enriched form.

Next to this comes the celebrated Chapel of the Pyx. This, as is well known, has long been held by the government. It formerly, I believe, contained the records of the Treasury, but now contains only empty cases and chests, with one exception, in which the paraphernalia for the trial of the pyx are contained. I have recently, through the kindness of the Chancellor of the Exchequer and the Secretary to the Treasury, visited, for the first time, its mysterious recesses: a formidable visit, requiring the presence of representatives of the Treasury and the Exchequer, with their attendants, bearing boxes which contain six mighty keys. It occupies two bays of the Confessor's work, a detached column standing in the centre. This column bears marks of a partition having at one time abutted against it, on one side of which the capital has been made round and slightly enriched, while on the other it has undergone no alteration but the rough canting off of its angles, as if preparatory to further alteration. The column which is partly built up in the north wall is on this side altered exactly as on the other, where it is seen in the adjoining chamber, showing that there was no partition against it. That on the south side I was not able to examine, owing to the presses by which it is concealed. The portion of it which is visible on the other side of the wall is one of those in which I have found the capital unaltered, and I was curious to see if the opposite side was so too; but was disappointed. In one of the eastern bays of the chapel the stone altar remains nearly entire. It is perfectly plain, and has in the middle of its top a large circular sinking, apparently for the reception of a portative altar-stone, though the form is, I believe, unusual. Adjoining the altar is a detached piscina, in the form of a column: it appears to be of the thirteenth century. The windows, which are very small, and probably of the same date, are doubly and very closely grated, —and well they might be so, for we learn that during the reign of Edward I. the king's treasury here was robbed of £100,000, which he had laid up here for the Scotch wars, for which the abbot and forty monks were sent to the Tower on suspicion. I fancy that the chamber was brought to its present form and its security increased after that event. Of the contents of the pyx chapel I will speak presently. The bays of the early work beyond the cross passage to the little cloister are simply waggon-vaulted,* as is that passage itself, as well as that which is called the Dark Cloister, which I suppose to be of the same age. Of the walls of the dormitory† itself considerable portions remain. Several of its walled-up windows are visible in the great school, and the exterior of one remains little altered excepting by decay: it has a shaft in each jamb, and is like Early Norman windows.

The only other part which is at all likely to have belonged to the Confessor's buildings is a part of the south wall of the refectory, in which a round-arched wall-arcading is still to be traced. As the Confessor increased the number of monks to seventy, he would want eating as well as sleeping room in due proportion; and in the absence of opposing evidence it is likely enough that this may be a portion of his refectory.

The next building which I will notice is the Chapel of St. Catherine, a work of the succeeding century. It was the chapel of the infirmary, and occupies a position not dissimilar to the corresponding chapels at Canterbury, Ely, and Peterborough.

The usual form of infirmary of a monastery was very similar to that of a church, with this simple difference, that the quasi-nave was very long, and was divided, at about one-third of its length from the east, by a cross wall perforated only by a central doorway; the western portion forming the infirmary proper, the eastern portion being the nave of the chapel, and a chancel extending still further to the eastward. This arrangement allowed the sick monks to hear the services as they lay in their beds, while the convalescent could readily transfer themselves to the chapel. This may still be traced out at Canterbury, Ely, and Peterborough; and there is a nearly similar building still in use (though unconnected with the cathedral) at Chichester; as also, with more or less variation, at Bruges, at Lubeck, and I dare say many other places. Now I imagine it is possible that the Westminster infirmary may originally have been of the same description. The chapel, of which the remains are sufficient to show its plan, agrees with it precisely; but the infirmary proper is gone, and may, I fancy, have been destroyed when the small cloister was built. If so, it no doubt extended westward to the wall in the dormitory. This however is a mere suggestion, and would be disproved if the small cloister can be proved to be of early date, which I see that Widmore imagines it to be. In that case I should suppose that the infirmary surrounded it.

I have recently discovered an old hall of the date of Abbot Litlington, who is known to have built a new house for the infirmarer. It abuts upon the south side of St. Catherine's chapel, and has a doorway into the chapel. It was no doubt the hall of the infirmarer's house, and was probably used by the convalescent patients. The garden now called the College Garden, was originally the infirmary garden.

The chapel consisted of a nave and aisles, of five bays long, with a chancel of which I cannot ascertain the length. It is very good Late Norman, and in its details much resembles that at Ely, even to the setting of the octagonal columns angle foremost, but it is less rich. The west doorway is of Abbot Litlington's time (temp. Edw. 3 and Rich. 2). The pier of the chancel arch was discovered last year, while making alterations in an adjoining building, but was unfortunately destroyed before I could see it. The hall I have mentioned had a gallery extending over the aisle of the chapel, with a fireplace in it. I have been able to preserve and expose to view the hall, with the exception of this gallery, which I was unable to save, though its fireplace still exists. The parts of the chapel which were formerly inclosed in the adjoining building are now exposed to view.

The only other Norman remains that I am aware of are some rather rich fragments found under the nave floor when the new stalls were being erected in 1848. I see that in the time of Henry II. or thereabout, stalls are mentioned as being made for the "new work." This looks as if the western part (which contained the stalls) had been rebuilt; but I am inclined to think that the new work was the chapel of St. Catherine just built, the altar of which is said to have ranked second among them all. I must apologise for dwelling so much at length on these early features. I have done so because they are generally but little known.

I now come to the existing church, a building which does not owe its claims upon our study to its antiquarian and historical associations, intensely interesting though these must be to every man worthy of the name of an Englishman. It has claims upon us architects, I will not say of a *higher*, but of *another* character—on the ground of its intrinsic and superlative merits as a work of art of the highest and noblest order; for though it is by no means pre-eminent in general scale, in height, or in richness of sculpture, there are few churches in this or in any other country having the same exquisite charms of proportion and artistic beauty which this church possesses. A beauty which never tires, and which impresses itself afresh upon the eye and the mind however frequently you view it, and however glorious the edifices which during the intervals you may have seen; and I may add, which rides so triumphantly over the dishonour which under the name, for the most part falsely assumed, of *high art* more modern ages have ruthlessly heaped upon it.

The period of the erection of Westminster Abbey was one of the great transitional epochs of our architecture. During the latter half of the twelfth century, the Romanesque or round-arched Gothic had both in France and England transformed itself by a thoroughly consecutive and logical series of changes into the

* These waggon-vaults are formed of tufa laid in rubble-work, and still showing the impressions of the boards of the centering on the mortar.

† The dormitory was partially burnt in 1448.

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pointed arched style, and in both countries that style had been worked into a state of perfect consistency, and in each it had assumed its national characteristics, so that the works in the choir at Lincoln, the lady-chapel at Winchester, and the western portals of St. Alban's and Ely, all of which date from 1195 to 1215, mark the perfectly-developed Early English style, and are readily distinguishable from the contemporary works in France.

The English works of this period have, at least to our eye, a more advanced appearance than the French. The round form of the abacus, the greater richness and delicacy of the mouldings, and generally a more decided severance from the massiveness of the Romanesque forms, give to the works I have alluded to a later appearance than what we observe in buildings of the same precise period in France. The leading characteristics were however much the same. The windows especially, in both countries, consisted for the most part of individual lights placed either singly or in groups. The chief variety from this was when, as was usual in the triforium openings and in belfries, two or more such lights were placed under a comprising arch, the interval below which was very usually pierced with circular or other openings. This was not, chronologically speaking, a step in advance of the detached light, but had all along been its contemporary, whether in the Romanesque, the Transitional, or Early Pointed styles, and both were equally in use in France and England. In domestic work, the last-named type (that with two or more lights under a comprising arch) was always prevalent, on account of the smallness of the intermediate divisions, which, from an early period, it was customary to reduce to a thin shaft of marble or plain stone, as we see in our own country even in Romanesque works, as at the Jews' House and the building commonly called "John of Gaunt's Stables" at Lincoln, Fountains Abbey, Richmond Castle, &c. As a general rule however, the more detached form was for a long time the prevalent form in churches, both in France and England. The difference between the course pursued in the two countries was this: that while in England the special energies of the builders were directed to the perfecting of the more usual type, the French began early in the thirteenth century to show a preference for the other, and rather to neglect the perfecting of the more typical form. Both forms were frequent in each country, but the efforts of the English were rather directed to the one, and of the French to the other. The consequence was, that while in England the grouping of distinct lights was being brought to the utmost perfection, the French were engaged, more especially at least on a number of tentative steps towards what became afterwards the mullioned and traceried window. I will not attempt a history of this invention, but will just call attention to one or two of its steps. At Bourges we have the earlier type in its full perfection, the spaces between the comprising and comprised arches and the piercings of the head being a flat face. At Le Mans and Tours we find these spaces cut out parallel to the lines of the openings, not however moulded into what is called *bar* tracery, but as if sawn square through,—a very clumsy and crude contrivance, very inferior to the plate tracery it was intended to improve. At Rheims, so far as I know, is seen the earliest introduction of the perfected principle. We find there, for the first time as I believe, the pierced spandrils and gussets moulded as the openings themselves, and the principle of bar tracery completed, though with some remaining imperfections. It is very difficult to fix dates to these transitions. Rheims cathedral was commenced in 1212, and it is generally supposed that the first architect, De Coucy, completed the aisles in 1220 or 1225. M. Viollet le Duc, naturally enough, seems puzzled at finding perfect traceried windows at so early a period, and suggests it as probable, as the transept of the same work does not exhibit equal advancement, that the aisle windows were altered by him a little later. Certain it is that neither Bourges nor Chartres, which were built about the same time, give any evidence of a like progression; while the intermediate step at Le Mans and Tours would appear, from many of its accompanying details, to be of later date than that given to Rheims. Had Villars de Honnecourt put a date to his sketch-book, which gives these very windows at Rheims, the difficulty would perhaps have been solved.

The windows with similar tracery in Notre Dame at Paris, M. Viollet le Duc from internal evidence dates from 1235 to 1240. The cathedral at Amiens presents difficulties as to date almost equal to that at Rheims; but, in the whole, we may fairly suppose this development to have become pretty common in northern France by about 1230 or 1235, though not to the extent of superseding either the detached light or the plate tracery. Pierre de Montereau, the architect to Sainte Chapelle, in which the perfected tracery prevails, built also the refectory of St. Martin aux Champs, in which it does not appear at all.

During the same period, the peculiar and afterwards stereotyped French arrangement of the chevet, or the apse with its group of radiating chapels, had been brought, by many steps, to its final development.

Radiating chapels, growing out of the main apse or its aisles, had been early used. In this country we find them at Gloucester and Tewkesbury, and in the foundations recently excavated at Leominster, all of the Romanesque period; and later we find them at Pershore. The French characteristic, however, was the arranging of them in polygons fitting to one another and to the sides of the polygonal aisle of the main apse,—a sort of corona of little chapels mathematically fitted together, and their axes radiating to the centre of the apse, at or near which the high altar was usually placed. This we find in many tentative forms, but the system appears to have been brought to perfection at Rheims and Amiens,—the latter of which churches appears to have henceforth been taken as the type on which in the majority of cases, though subject to some varieties, the grouping of eastern chapels was founded, as at Beauvais, Cologne, Altenberg, and a host of other instances. The two German apses last named, I may mention however, seem to have had Beauvais rather than Amiens for their immediate type.

There can be little doubt that King Henry III. during his sojourns in France became enamoured of this arrangement, which in its perfected form he may have seen in course of being carried out at Amiens, Beauvais, Rheims, and elsewhere. It would naturally strike him as well suited to the reconstruction of the eastern portion of a church already possessing an apse with a continuous surrounding aisle. Whether this project had been formed when the lady-chapel was built in 1220, it is impossible to ascertain. This was begun in the same year with Amiens Cathedral, and eight years later than Rheims; so that it is not impossible, though the extreme youth of the king would in that case compel us to transfer the originating of the scheme from him to the abbot. However this may be, it is probable that it fell readily into the subsequently adopted plan, as we find no disturbance of the regularity of the division, which would otherwise have been the case.

Judging from internal evidence, which is all we have to go upon till the public documents and the archives of the Abbey are more thoroughly searched, I should imagine that an English architect or master of the works was commissioned to visit the great cathedrals then in progress of erection in France, with the view of making his design on the general idea suggested by them. Would that, like his contemporary Villars de Honnecourt, he had bequeathed to us his sketch-book! The result is precisely what might have been expected from such a course. Had a French architect been sent for, we should have had a plan really like some French cathedral, and it would have been carried out, as was the case with William of Sens' work at Canterbury, with French details. As it is however, the plan, though founded on that common in France, differs greatly from any existing church; and it contains no French detail whatever, excepting the work of apparently one carver. I have sometimes fancied that I could detect a French moulding in the water-tabling of the external buttresses, but these are themselves restorations, and are so decayed, that I cannot make sure of their section. If it be so, it is just one of those exceptions which prove a rule.

The architect however, in imitating the great contemporary churches in France, did adopt another of their great characteristics,—the bar tracery of their windows. I am not aware that it exists in a perfected form in any earlier English work, though often closely approached. It is said that Netley Abbey was erected about 1240, and the eastern part of old St. Paul's is said to have been consecrated in that year; and as both of these contained perfected tracery, the substantiation of those dates would establish for us an earlier claim; but, on the whole, I think we may fairly yield this development to our neighbours, and consider this to be about the period at which we borrowed it, though so perfect is the catena of transitional steps, that had it not been from external evidence we should have had no difficulty in tracing out the history of the development from English examples; the only step which I miss in them being that which I have given from Le Mans and Tours, on which however I have never heard any stress laid.

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This church is then remarkable as marking, first, the introduction of the French arrangement of chapels, which however failed to take root here; and, secondly, the completed type of bar tracery, which was no sooner grafted on an English stock than it began to shoot forth in most vigorous and luxuriant growth.

Though the French type was, as a general form, adopted in planning the chevet with its circlet of chapels, I know of no French church from which the actual plan could have been taken. The simplest mode of setting out the chevet with its chapels is that adopted at Rheims, which is effected by simply describing a semicircle upon the transverse line passing through the easternmost of the main range of columns, and of a diameter equal to the width from centre to centre of those columns, and inscribing in it a semi-decagon, whose angles will give the centres of the piers, the same operation being repeated for those of the aisles. At Amiens the system is different, the two semicircles are described, one for the piers, and the other for the aisle; and about each of these it would seem that the normal idea was that a portion of a dodecagon should be circumscribed; but in fact the sides are a little less than those of that figure. On the outer circuit of the aisle, seven angles of the quasi-dodecagon represent the centres of the piers between the radiating chapels, while on the inner circuit, five angles of the smaller quasi-dodecagon represent the centres of five of the piers of the apse; the two remaining piers being placed at the points where the transverse line which cuts off the seven sides of the outer apse intersects with the longitudinal lines which pass through the centres of the main ranges of piers. It will be seen that this gives a bay of a width intermediate between those of the apse and those of the main arcade, but in a line with the latter. The chapels are alike in the width of their arches, but differ in the westernmost sides of the western chapels not radiating in a regular manner.

The chevets at Beauvais and Cologne differ from that at Amiens in this, that the dodecagons are *in*scribed instead of *circum*scribed. It follows that only five of the angles of each dodecagon represent the angles of the outer or inner apse; the remaining angles of the former are found by spreading the figure outwards till it intersects with the line of the wall; and those of the latter, by drawing a transverse line from these points to its intersection with the longitudinal lines of the main range of columns as before. The consequence is, that the first side of the apse has a slight inclination instead of being parallel to the axis of the church.*

The chevet at Westminster differs greatly from any of the above. The sides of the apse are five in number, as at Rheims, but instead of being five sides of a decagon, the three easternmost are sides of an octagon, and the others incline but slightly from the sides of the church. The great peculiarity, however, is in the chapels, which occupy so much more than the semicircle as to do away with one of the non-radiating chapels, reducing the space it usually occupies to an irregular pier, and introducing opposite to it in the aisle a bay of very irregular form. I had long noticed this peculiarity, though I had thought it an irregular contrivance to give greater size to the apsidal chapels; but from finding the setting out of the work remarkably exact, I was led to think that some mathematical principle must have been acted on, and having had most careful measurements made and tested in every way, I find this to have been the case.

The system is this: the two semicircles are drawn as before, the diameter of the inner one being the width from centre to centre of columns. A semi-octagon is inscribed in this; three of its angles give the centres of the piers of the outer and inner apses, the remaining sides of each apse being formed by spreading them till they meet the main longitudinal lines. It most resembles the principle followed at Beauvais, but differs from it (besides the smaller number of the sides) in the outer and inner apse being exactly alike in principle and all their sides equal, and both set out in regular radiating lines, instead of using the transverse line adopted at Beauvais. This system has great advantages: it avoids the narrowness of the apsidal bays so apparent in most of the French examples; it gives a beautiful gentleness of transition from the main arcades into the apse, and it also gives a great boldness and expanse to the chapels,—advantages purchased cheaply at the expense of one of the square chapels on either side, and a certain degree of picturesque irregularity in the aisles. It should be mentioned that the setting out of this church is remarkable for its regularity and exactness, though the drawing of an intricate mathematical figure on the ground, some 120 feet wide, necessitated some trifling deviations from absolute precision.

The section of the church also differs much from that of the great contemporary buildings in France. The earlier French Pointed churches had retained the Romanesque system of having, not a mere triforium, but a distinct upper story over the aisles, often with a second range of vaulting. The same occurs (though not vaulted) in many of our own Early Pointed churches, especially where they resulted from the piecemeal reconstruction of their Norman predecessors. At Amiens and Rheims, as at Salisbury, Whitby, Rievaulx, and indeed the majority of our churches of the thirteenth century, this second story was represented only by the space intervening between the roof and vaulting of the aisles. At Westminster however, for some special reasons, the second story, which we know to have existed in the Confessor's church, was continued in its successor, probably to admit more numerous spectators on grand occasions, such as coronations and royal funerals. It was obtained not so much by increasing the height of the triforium arcade, as by flattening the aisle roof so as to allow of a wall of considerable height to the triforium, the story being lighted by short windows of a quasi-triangular form filled in with cusped circles. The spaciousness of this upper story is quite surprising to those who see it for the first time. It is capable of containing thousands of persons, and its architectural and artistic effects as viewed from different points are wonderfully varied and beautiful. I have sometimes doubted whether, however, this arrangement was contemplated when the building was commenced. There is about the intersection of the aisle roof with the flying buttresses a want of system which does not seem of a piece with the studious exactness of other points of the design, but is more like the result of an alteration of the design during its execution. It gives also to the transept elevation a high-shouldered look, which is detrimental to its elegance, and, while it adds to the external importance of the aisles, it rather takes from the dignity of the clerestory by concealing its natural spring from behind the abutting roof of the aisles.

I may mention that the very same arrangement was followed in the contemporary work in the north transept at Hereford; indeed, the very cuspings of the circular windows which I have recently discovered there seem to be exactly copied from those in the same position at Westminster.

Of the mathematical proportions on which the design of the church has been founded it is hardly safe to speak. This is a subject on which so much uncertainty, and consequent difference of opinion exists, that it would be unwise to be dogmatic, or to adopt any theory too positively. The proportions are, however, so pre-eminently satisfactory to the eye, that it is not unprofitable to examine into them; for, whether the result of accident or intention, the lessons to be learned are the same: indeed, it is perhaps almost more instructive to find that proportions arrived at by tentative experiments and a correct eye coincide with some mathematical principle, than, after trying many geometrical formulæ, to find one which gives a result satisfactory to the eye. That beauty of proportion may be reduced to mathematical principles I have no doubt, but as mathematical forms are of infinite variety, and of very unequal beauty, while the reasons why one is more pleasing to the eye than another are, to say the least, very occult, it seems to follow that the laws of proportion must be investigated by a process partly tentative and partly geometrical; the proportions dictated by the eye and those resulting from mathematical forms being mutually tested the one by the other, till we are able to determine which set of geometrical proportions is most beautiful, and which among the forms which please the eye are capable of being reduced to mathematical proportions.

As an illustration of this, I remember, many years since, while looking at a plate in 'Britton's Antiquities,' in which he gives internal arches from a number of our cathedrals, I set myself the task of determining which were the most beautiful in their proportions. To my surprise I was compelled to choose the two which apparently most differed the one from the other, in fact the tallest and the shortest of the set. I was perplexed at so contradictory a result, but, as I could not go against the dictates of my eye, I endeavoured to investigate the cause, and had much pleasure in finding that both (as shown in the drawing at least) might be resolved into equilateral triangles,—the Westminster arch having three, and that from Wells only two of them in

* These definitions are open to some modifications for irregularites admitted in the setting out.

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its height. I have somewhere heard, that in an old work of the Freemasons it is said, that good proportions may be obtained from the square, but better from the equilateral triangle; and I have little doubt that it is true.

If the principle of the triangle is applied in the present case, the main section may be said to have a height of three equilateral triangles described upon the transverse width of the church from centre to centre of the columns, which dimension seems in all churches to have been taken as the elementary scale on which the proportions were founded. Another proportion common in old works is derived from the diagonal of the square of this measure. Both have been claimed as the system made use of at Westminster; but the more closely one examines into it, the more clear it is that the equilateral triangle is the figure actually made use of. I have made careful measurements, and find it fully established that this is the case. I find that the elementary width is about 5 inches greater in the transept than in the choir and nave. Possibly it had been affected in the latter case, as it would appear to have been in the aisles, by some particular cause, for the difference is clearly not accidental, being most systematically carried out and adhered to throughout to a fraction. If we take the larger of these dimensions it will be found to agree very closely indeed with the different parts of the church. The height of the nave exceeds the three triangles only by about 8 inches. The height to the triforium string-course exceeds half that dimension, or the three triangles of the semi-scale, by only 4 inches; and the height of the triforium itself is 4 inches in excess of one of these minor triangles: differences so small as to be invisible in so great a height. This agrees with the theory laid down by Professor Cockerell, in his excellent paper published by the Archæological Institute in their Winchester volume. He defines it in this way: that if you assume double aisles to the nave (*i.e.* if you triple the elementary width), the equilateral triangle described on this width will give the height of the vaulting. In the ichnography the proportions are far less exact. The idea would appear to be that the length of the church should consist of four, and the length of the transept of two of the heights of the great triangle last named. This is however by no means exact, and one cannot lay much stress upon it.*

I may here mention that the same system holds good in the chapter-house, of which the height agrees with that of an equilateral triangle described on its diagonal; or, more properly, each of its arches from the central pillar to the angle-shaft has the height of two triangles, or of a regular vesica piscis.

The details of the internal design greatly exceed in richness those of French works of the same age, excepting only in the extent to which the capitals are foliated. The arch mouldings are peculiarly beautiful. The triforium arcade is as beautiful as any which can perhaps be found. That to the eastern part of Lincoln may be almost richer, but its proportions yield in beauty to those of Westminster. The richness of the whole is also vastly increased by the wall-surfaces between the arches being enriched with a square diaper. The wall-arcading is of exquisite design, and the spaces over it were filled with most beautiful foliage with figures interspersed, while the spandrils of the cusping were filled with ornamental painting. When to the richness of architectural detail we add that of material —the entire columns and all the subordinate shafts being of marble, and the remainder of stone of several different shades of colour—the magnificence of the internal design must have greatly exceeded that of its French prototypes. The only one point which strikes the eye as looking less rich is the use of merely moulded capitals to the main pillars. This, however, arose from their being of Purbeck marble. It is true that at Ely and elsewhere, as in our own chapter-house, the carved capitals are of this stubborn material; but its use may, nevertheless, be accepted as a fair excuse for moderating the workmanship. The internal designs of the transept ends are truly magnificent; indeed, I doubt whether their equals can be found elsewhere. The manner in which they continue the lines of the general design, and yet add diversity to the forms, is truly artistic.

It is most unfortunate that the great rose windows have lost their original character. I have however a strong impression that the old ones may have, in their leading subdivisions, resembled that now existing in the south transept, and that the design has been simply translated from that of the thirteenth to that of the fifteenth century. I have attempted in the accompanying drawing to translate it back again; and you will see that it makes a very fine window, in perfect accordance with the character of the church, and very much like several existing specimens. You may say that this is pure conjecture,—and so it is; but it is a conjecture not devoid of some collateral corroboration; for, singularly enough, there exist in the chapter-house some encaustic tiles of a pattern evidently copied from a rose window, and agreeing precisely in its divisions with that under consideration, representing even the shafts, with their caps and bases. It will be seen that my translation of the existing window into Early English almost precisely resembles the pattern given on those tiles. The square form in which the circle is inscribed seems to be original, from the systematic way in which the vaulting is accommodated to it; but it must be admitted on the other hand, that there are in the eastern jamb of the south window some indications of the design having been altered from the original intention; though, as I think, this was an alteration made during the progress of the work, as neither the opposite jamb of the same window nor either jamb of the opposite window shows any such indications. The south window was, I believe, renewed in the fifteenth century, and again in the seventeenth century. Sir Christopher Wren informs us that it had been renewed about forty years before the date of his report. The north window received its present form in the eighteenth century, and in no degree resembles its predecessor. Whether that which Sir Christopher Wren reports to be in a dangerous state was the original one, there is no means of telling.

The works undertaken by Henry III., and completed in 1269, terminated immediately to the west of the crossing: the line of junction can be readily traced. I think the older work may have included one bay of the great arcade and aisles, or, to say the least, some of its details were continued in that bay; but in the first clerestory window of the western arm the change is clearly seen in the diversity of its eastern from its western jambs.

The five bays west of the crossing are the work of Edward I. They differ chiefly from the work of his father in the plan of the columns, which have four attached and four detached shafts (the latter in most instances secured by fillets of brass); in the greater number of the ribs of the vaulting, and in the substitution of shields for carved enrichments in the spandrils of the wall arcading. The rib-moulds of the vaulting are also different: the capitals of the wall-arcading are moulded instead of being carved; and the triforium has no enrichments in its arch mouldings; but in the main the design may be considered to be the same. In both the carved foliage is at the point of transition from the conventional to the natural. It is not in any degree *intermediate* between the two, but they stand on equal terms side by side, each in its integrity, and each excellent of its kind.

Unhappily however, the sculptors of more recent times, convinced that Gothic architecture is discordant with their own "high art," have shown such praiseworthy determination in destroying, root and branch, the discordant element; and the destructive atmosphere of London has shown so strong a sympathy with the practitioners in high art, that between the two we have little left of the carving of the lower parts (on which the greatest amount of study had been expended), but a few mutilated and crumbling fragments—"the gleaning of the grapes when the vintage is done." These melancholy relics are, however, sufficient to show us the value of what we have lost.

I have before mentioned that the hand of one French carver may be traced in the work. This is the case chiefly among the capitals of the wall-arcading. Many of these are of the English type of the period, but amongst them are two kinds, both of which are in their carving distinctly French. The one is the crotchet capital, the stalks of which are terminated, not as in English work with conventional, but with exquisite little tufts of natural foliage, such as may be seen in the wall-arcading of the Sainte Chapelle and many other French works of the period. In the other, natural foliage is introduced creeping up the bell and turning over at the top in symmetrical tufts. In both the foliage is smaller and less bold than in French work, and the architectural form of the capital is English.

The spandrils over the wall-arcading are exquisitely beautiful. Some are only diapered in square diaper like the spandrils of the triforium; some with conventional and some with natural foliage, with or without figures; and some with subjects. Those in the western arm contained shields of a large number of the great

* From further examination since writing the above, I believe that both in the aisles of the nave, and in the lengths of the church and of the transept, the proportion reached to the centres of the walls, instead of (as was more usual) their internal face; if so, the last-named proportions would be almost exact.

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men of the day. The great majority have given place to modern monuments, but the few which remain are nobly executed. They are curiously hung by the armstraps to projecting heads. In those parts of the triforium which cross the ends of the transepts, there have been figures in all the spandrils. Of these, the two central ones in the north transept are gone, and the corresponding figures in the south transept are much decayed, but those in the angles of both, being executed in a superior material, are more or less perfect. They all represent angels censing, and are exceedingly fine, after making due allowance for the height at which they were intended to have been seen. I exhibit casts of two of them, which are however somewhat roughly taken, and do not do them justice; also sketches of the other two. Below these, in the north transept, there are figures in the window jambs, and busts of angels in medallions in the soffits of the window heads. They are shown as bearing musical instruments, &c., forming what is called a "Divine liturgy." They seem to have been well executed, though now much decayed.

The bosses of the vaulting are generally very nobly executed, particularly those over the choir (I mean Edward I.'s work, west of the crossing), some of which are among the finest I have ever seen. Several bosses in the western aisle of the north transept contain well-executed figures and groups surrounded by foliage.

Of the original details of the exterior it is nearly impossible to form anything like a correct idea. The whole was greatly decayed at the commencement of the last century, and was recased almost throughout with Oxfordshire stone, by Sir Christopher Wren and his successors; the details being altered and pared down in a very merciless manner. and the work thus renewed has again become greatly decayed. There is, in fact, scarcely a trace of any original detail of the eastern portion of the exterior left. The modeller employed by Sir Christopher Wren seems to have had more respect for the details than his master; for, while the latter has destroyed the external shafts of the windows, and represented their capitals by huge ungainly acorns, the modeller has in several instances shown the originals quite faithfully.

The exterior is thus described by Keefe in 1683:—"On the north side you rather behold the skeleton of a church than any great comeliness in her appearance, being so shrivelled and parcht by the continual blasts of the northern winds to which she stands exposed, as also the continual smoaks of the sea-coal, which are of a corroding and fretting quality, which have added more furrows to her declining years, that little of her former beauty now remains. On this side is a most noble door or portal, with a porch thereunto, that opens into the cross of the church, and on each side thereof two lesser porticos, one of which only serves at present for the convenience of entering therein. This porch in former times hath been of great esteem and reputation, assuming to itself no less a name than that of the Porch of Solomon. That it hath been a curious, neat, and costly porch in foregoing times, the remains thereof do at this day in some measure declare, for therein were placed the statues of the Twelve Apostles at full proportion, besides a multitude of lesser saints and martyrs, to adorn it, with several intaglios, devices, and fretworks, that helped to the beauty thereof. But that it came in any proportion to the stately, rich, and noble porch of King Solomon is not to be imagined; nor can we think that those who christened and gave it that name were so ignorant or so vain to believe it; but as a thing excellent in those times, and far surpassing any of the same kind, it was looked upon as a piece of work well deserving no common name, and therefore had the title of Solomon's Porch appropriated thereunto."

Crull, writing in 1711, says,—"The very remnants which are obvious to our sight, even to this day, may soon convince us of its ancient beauty and magnificence. For this portico still retains entire, below, two of these admirable statues, besides two others quite defaced, and two more over the eastern part of the portico, and as many over the western door, through which you enter on the north side, pretty entire, being all undeniable witnesses of their former excellency."

These magnificent portals formed, beyond a doubt, the most sumptuous external features of the church, and should be especially mentioned as another imitation from French cathedrals. It is curious that this is, so far as I am aware, the only instance in which those glorious portals, so common in France, were directly imitated in an English church From the existing remains, as well as from the above description, the portals must have been gorgeously rich. There are a number of mouldings still existing in the original stone, and which clearly contained rich foliage like that still remaining in the doorway to the chapter-house, but now carefully cut out. The places where the figures of the Apostles stood are readily to be distinguished, and an old print shows one also on the central pillar of the doorway, no doubt a figure of our Lord.

The tympana of the smaller openings retain their original stone, which is decorated with circular panels, no doubt once containing sculpture, but the great tympanum is renewed, apparently without any regard to the original form. There were formerly gabled canopies to each portal, but now the central one has an ogee canopy and the others none. The whole of this once magnificent front has been wretchedly tampered with, and even the design of the rose window is altered from the form shown in the old prints to one of miserable poverty.

Dart, writing in 1723, says,—"This stately portico is now lately beautified, the time-eaten sculpture and masonry pared away, the *Gothic* order justly preserved, and the whole adorned with a magnificent window designed by the ingenious Mr. Dickenson, surveyor of the building."

I should mention that the name of "Solomon's Porch" was, I believe, really applied to a large porch erected against the central portal in the reign of Richard II.

It is a question on which much difference of opinion exists whether a central tower was ever contemplated. This feature was nearly universal among the great English churches of the period; but as this church was designed on a French type, and as the churches of the period in France very seldom have central towers, it seems most natural to suppose that it was not intended to have erected one here. On the other hand, Sir Christopher Wren distinctly states that the commencement of a tower existed in his time; indeed, in one of Hollar's views there are clear indications of it (and internally it is evident that the centre was not intended to be vaulted at the level of the nave and choir). M. Viollet le Duc also seems to think that even in France this feature has often been contemplated; so that it seems that there is as much to be said on one side as on the other. I cannot, however, think that the comparatively slender piers on the crossing (to the extreme beauty of which I should have especially called attention), could have been intended to carry, at the most, more than a very slight structure. Even at Salisbury, where the piers are far more massive, the lower story of the tower is very lightly built, and clearly without any intention of supporting the enormous superstructure which has since been added, and under the weight of which it has become so terribly crushed.

The cloisters were carried by Henry III. and Edward I., in each case, as far only as their respective portions of the church extended. That part built by Henry III. occupies, as is so well known, a very singular position, being in fact within the walls of the church, and forming a lower story to the western aisle of the transept. This, as I conceive, arose from the position of the cloister being determined by the older works, and from the church of the Confessor having had no western aisle to the transept. King Henry, however, built the eastern wall of the cloister a few bays further than the cloister itself, for the purpose of forming entrances to the chapter-house and dormitory. Edward I. afterwards carried in the north wall of the cloister just as far as he did the church itself. The other bays of that side were built late in the fourteenth century, in imitation of the older bays, an almost solitary instance of the style of one period being absolutely copied in a later work. We find here, at the corner where they resumed the style of their own period, the singular anomaly of an Early English and a Perpendicular capital on the same block of stone, and their mouldings intersecting one another. The late imitators seem to have been sorely puzzled with the detached cuspings in the old circles, and to have made some very awkward attempts at reproducing it.

The doorway from the church next the cloister is a very fine work, but in a lamentable state of decay. The window openings of the early parts of the cloister have been glazed in their traceried heads only, the glazing being stopped upon a horizontal iron bar grooved at the top to receive it, and running along the springing line of the arch. This system was continued in the latter work; indeed it was, I find, the customary mode of dealing with cloister openings. Those at Salisbury, Canterbury, and Gloucester, works of very different periods, were, I think, all of them glazed in this manner.

In the church we have no windows of more than two lights, so that the tracery is in its most normal form. In the cloister, however, the windows are of three lights, and the tracery is not

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only in circles, but in quatrefoils and trefoils; while, in the chapter-house, as we shall presently see, were windows of four and five lights, showing that the principle of window-tracery had been brought to a considerable pitch of development.

In all the circles in the tracery, whether in the church, the cloister, and no doubt in the chapter-house, the cusping was, according to the custom of the period, worked separately from the tracery, and fitted into grooves in its reveals, while the heads of *lights* are almost always left uncusped, the chapter-house forming, I think, nearly the sole exception.

One feature, more French than English, I may mention here; I mean the great width of the window-lights, which are generally between 4 and 5 feet wide, and must have afforded a noble scope to the glass painter.

We now come to the Chapter House.

Matthew Paris, under the date of 1250, says, after stating that the king had rebuilt the church, "Dominus rex ædificavit capitulum incomparabile." I judge from this that he commenced it during that year. It was indeed an incomparable chapter-house! That at Salisbury was not yet commenced, and though evidently built in imitation of this, and having some features of greater richness, it still would have yielded the palm to its prototype at Westminster. Its beauties however are, unhappily, now for the most part to be judged of rather by imagination than by sight, for seldom do we see a noble work of art reduced to such a wreck! It appears that as early as the days of Edward III. (certainly before 1340), it was made over, I suppose occasionally, to the uses of the House of Commons, on condition that it should be kept in repair by the crown. In or after the reign of Edward VI. however, St. Stephen's Chapel being given up to the House of Commons, the chapter-house was converted into a public record office. In or about 1740 the vaulting was found to be dangerous, and taken down; and before this, in 1703, we find that Sir Christopher Wren having refused to put up a gallery in it, it was made over to the tender mercies of some barbarian, who fitted it up for the records, with studious regard to concealment or destruction of its architectural beauties.

I undertook, some years back, the careful investigation of its details, and such was the difficulty presented by the fittings and other impediments, that, though every possible facility was afforded me by the gentlemen in charge of the records, it occupied me (on and off) for several months.

I believe, however, that I succeeded in getting at nearly every part of the design. The internal view which I exhibit was founded on the result of my examinations, and I think you will agree with me that a more elegant interior could scarcely be found. The diameter of the octagon is about 58 feet, and the height to the crown of vaulting about 54 feet. The diameters of those at Salisbury, Lincoln, and York seem all to be nearly the same with this; probably the polygons were in each case inscribed in a circle of about 60 feet diameter, measured perhaps in the clear of the vaulting shafts.

The central pillar still exists, and is about 35 feet high. It is entirely of Purbeck marble, and consists of a central shaft, surrounded by eight subordinate shafts attached to it by three moulded bands. The capital, though of marble, is most richly carved. I may mention that on the top of the capital is a systematically constructed set of eight hooks of iron for as many cross ties. The same was the case at Salisbury, and I have no doubt that the hooks on the columns in the church are many of them original, and were intended for security during the progress of the works. The windows are almost entirely walled up, though a considerable part of the tracery, no doubt, remains imbedded. Their design is however readily ascertainable, one of them being a blank, owing to one face of the octagon being in contact with the transept of the church: a nobler four-light window could scarcely be found.

The window over the doorway is most carefully walled up with ashlar, but from the vases visible on its cill we see that it was of five instead of four lights,—no doubt to avoid the stumped look it might have had from being so much shortened by the height of the doorway and the abutting vestibule. I had often wondered that, while the windows generally are walled up with brick, this should be filled with stone; but, on taking out one of the ashlar stones to ascertain the section of the jamb, what was my surprise at finding them to consist entirely of the lengths of the moulded ribs of the lost vaulting, carefully packed like wine-bottles in a bin, with their moulded sides inwards.

I made a still more interesting discovery in the spandril of the doorway below. The gallery crosses the head of this doorway, and the presses for records were fitted so closely to the wall that nothing could be seen. I was one day on the top of one of these presses, and on venturing to pull away an arris fillet which closed the crevice between it and the wall, I perceived the top of an arched recess in the wall behind the press, and on looking down into it I saw some round object of stone in the recess below. My curiosity being excited, I let down into it by a string a small bull's-eye lantern, when, to my extreme delight, I saw that the mysterious object was the head of a beautiful full-sized statue in a niche. Permission was speedily obtained for the removal of the press. The statue proved to be a very fine one of the Virgin, and in the spaces adjoining were angels censing. I afterwards found that it formed part of an Annunciation, the angel having been on the other side of the door. This last-named figure has however been long since removed into the vestibule: its wings are gone, but the mortices into which they were fixed remain. Both are fine works, though not devoid of a remnant of Byzantine stiffness. The doorway itself has been a truly noble one. It was double, divided by a single central pillar and a circle in the head: whether pierced or containing sculpture I have been unable to ascertain, as it is almost entirely destroyed. The jambs and arch are magnificent. The former contain on the outer side four large shafts of Purbeck marble: their caps are of the same material, and most richly carved, and the spaces between the shafts beautifully foliated. I exhibit casts of several parts of this doorway. The arch contains two orders of foliated mouldings, one of which on either side contains a series of beautiful little figures in the intervals of the entwined foliage. To get at some of the details of this doorway I had to creep on a mass of parchments and dust 10 feet deep; and, after taking out the boarding of the back of the cases, to examine, and draw, by the help of the little bull's-eye lantern before mentioned,—a most laborious operation, and giving one more the look of a master chimney-sweeper than an architect.

The walls below the windows are occupied by arcaded stalls with trefoiled heads. The five which occupy the eastern side are of superior richness and more deeply recessed. Their capitals, carved in Purbeck marble, are of exquisite beauty. I exhibit casts of some of them. The spandrils over the arches are diapered, usually with the square diaper so frequent in the church, but, in one instance, with a beautiful pattern of roses. One of the most remarkable features in the chapter-house is the painting at the back of these stalls. The general idea represented by this painting would appear to be, our Lord exhibiting the mysteries of the redemption to the heavenly host. In the central compartment our Lord sits enthroned; his hands are held up to show the wounds, and the chest bared for the same purpose; above are angels holding a curtain or dossel behind the throne, and on either side are others bearing the instruments of the passion. The whole of the remaining spaces are filled by throngs of cherubim and seraphim. The former occupy the most important position, and are on the larger scale. In the two niches to the right and left of the central one are two cherubim, nearly of human size. They occupy the centre of the niches, and with their wings nearly fill them. Their heads are of great beauty and are very perfect, and apparently painted in oil. They have each six wings, two crossing over their heads, two spreading right and left, and two crossing over the knees. The prevailing colour of the wings is blue—the symbolical colour given to cherubim—and the feathers have eyes like those of the peacock, to carry out the idea, "they were full of eyes within." One of these principal angels holds a crown in each hand, and the other has a crown in one hand and something like a gem with two depending strings in the other, symbolising the rewards of heaven purchased by the redemption. On one of them the names of Christian virtues are written on the feathers of the wings, as, *e.g.*—Officii sincera plenitudo; Voluntatis discretio; Simplex et pura intentio; Munditia carnis; Puritas mentis; Confessio; Satisfactio; Caritas; Eleemosina; Orationis devotio; Simplicitas; Humilitas; Fidelitas; &c. In the outer niches were several cherubic figures of smaller size, their faces strongly expressive of sorrow at seeing the wounds of the Saviour; and in the background above and the foreground below are throughout a multitude of seraphim, whose prevailing colour is as usual red, and the expressions of the faces most striking. All the figures have gilt nimbi of rich patterns. The whole is executed in a highly artistic manner, and though the features are in some cases not quite consistent with the idea of angelic beauty, the expres-

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sions are very striking. I imagine the painting to have been executed about the middle of the fourteenth century, which is, I find, the same as the opinion arrived at by Sir Charles Eastlake. In some other parts of the arcade are paintings of a very inferior character and of much later date. They represent the earlier scenes in the apocalypse. I have not noticed any merely decorative painting, excepting in the heads of the five principal stalls, which are coloured and gilt.

(*To be continued.*)

REMARKS ON THE BUILDING STONES USED IN MANCHESTER.*

A stranger visiting Manchester, on having his attention directed to the modern buildings in it, will doubtless notice the substantial nature of the bricks of which they are built. Of the stone employed for building, he will most probably be of opinion that it is not of the most enduring character for the climate and atmosphere it is subject to, and the unfair usage with which architects and builders think proper to test it. For however well it may be established in theory, that a sedimentary stone in a building ought to lie in the same position as that in which it was originally deposited in the earth, unfortunately in practice architects will persist in attempting to make the stone accommodate itself to their designs of buildings, rather than design their buildings in accordance with the nature of the stones they have to employ. No doubt beds of stone of great thickness and uniform composition are difficult to find, especially in sedimentary rocks, but still that is scarcely an excuse for placing it on its end or at right angles to the planes in which it was deposited.

Of late years a considerable number of experiments have been made as to the strength of building stones, just after they have been taken from the quarry, by pressure. This no doubt will give an idea of their power of resisting force at the time of the experiment being made, but it will give little evidence of the strength of a building stone after some years of exposure to a climate and atmosphere similar to those which the building stones of Manchester are exposed to, without the stone is of a pure silica, or nearly so. In all stones which are subject to chemical decomposition, these experiments will not surely guide us.

Old buildings in country places remote from the smoke and gases of large towns are often adduced in evidence of the strength and durability of a stone to be employed in a manufacturing town. However well the dolomite of Bolsover Moor might endure the climate and atmosphere of Southwell, in Notts, as it is seen in the minster there, or the triassic sandstone of Furness might endure in the abbey of that name, each seven or eight centuries, still it would be unreasonable to expect that either of those stones could resist the action of the moist climate of Manchester, and the atmosphere of a city in which about forty thousand tons of sulphur are annually burnt in the coal consumed in it, to say nothing of the gases given off by the numerous chemical manufactories and the exhalations from half a million of human beings.

On examining the buildings of Manchester, we find that the stone employed is chiefly from the middle and lower coal measures, the only instances of triassic or new red sandstones having been used are, as I have been informed, the Portico and St. Peter's Church, from the Oughtrington quarry, near Lymm, and the church lately built by Mr. Crowther at Moss Side, which is from Hollington, near Ashbourn.

The cathedral was built from the sandstones of Smedley and Collyhurst, two rocks belonging to the upper part of the middle coal field. These stones are both soft, and contain a large amount of clay and peroxide of iron. As you proceed further down into the middle coal field, you find the sandstones containing less iron in a state of peroxide and considerably smaller proportions of clay, still the stones are not suitable for outside work, as they contain protoxide of iron and sometimes sulphuret of iron, which are scarcely to be seen in the white sandstone when first obtained from the quarry, but on exposure to the atmosphere the iron becomes further oxidised, and the stone "bleeds," and becomes discoloured, as well as decomposed. It may be safely concluded that there is no quantity of good building stone, suitable for outside building in a city like Manchester, to be procured from the middle coal field.

* Read by Mr. Binney at the Literary and Philosophical Society.

The lower coal field and the millstone grit yield the only good building stones for Manchester. These strata comprise the beds lying under the Arley or Royley seam of coal and the limestone shale, and from their being generally found on the high land of the district, are known by the name of High Moor Stone.

As all the lower coal field and millstone grit beds have most probably been formed of the *debris* of granite or granitoid rocks, we find in them the proportions of silica, alumina, potash, iron, lime, and magnesia generally met with in those rocks. As a general rule, the more pure silica the rock is composed of, the better building stone it is. A mixture of mica or clay causes the rock to be more schistose or flaggy, as well as softer. Two chief beds of flags, besides several smaller ones, occur in this division, namely, the upper flag of Upholland, Catlow, and Holy Fold, lying between the Arley and Royley coals, and the lower flag or Bradshaw and Shawforth near Rochdale, lying under the rough rock and above the upper millstone grit. These flag beds yield the stone generally used for par point work.

A fine sharp grained siliceous grit is found sometimes above the gannister coal, as at Ending Common near Rochdale, which makes a good building stone.

A stone much used in building is the Halliwell, Woodhead Hill, or Lomax Wood rock, lying immediately under the salts or best coal of New Mills.

The rough rock, generally known as Summit and High Moor stone (the upper millstone of the geological survey), a stone much used in building, is of a coarser grain than the stones previously mentioned. It is composed of grains and rounded pebbles of translucent quartz cemented together with partly decomposed felspar and a little iron and manganese in the state of oxide. It is soft when first quarried, and works pretty freely, hardening when exposed to the air. As a building stone it is preferred, owing to its working much easier than the two millstones. Parbold, Horwich, Holcome Hill, Blackstone Edge, and Werneth Low are good examples of the stone.

The upper millstone of Holcome, Bank Lane, Todmorden, Saddleworth, and Tintwistle, is a hard and durable sandstone, composed chiefly of silica. It is much harder to work than the rough rock, and stands the weather better, but it is not in great use, owing to its being difficult to work. The lower millstone, as seen at Roecross and Rhodes Wood, Tintwistle, and the lower part of Pendle Hill, contains some excellent building stones, but they are hard to work and therefore have not been much used, but it is, no doubt, one of the strongest and most durable stones of the series. In the lower parts of it are some beds of fine grained sandstone, freer to work than the upper beds. A most excellent bed of this description is found at Bailey, near Ribchester.

In selecting a durable building stone for a town like Manchester, the more silica it contains the better. Iron or manganese in the state of protoxide, or sulphuret of iron, as well as clay, all damage the stone. The stones composed of silica cemented with silicates of soda, potash, lime, magnesia, or alumina, are all durable; but when clay or salts of iron form the cement the acids in the atmosphere have a very damaging effect on the building stones containing them.

The sandstones from the lower coal field in the neighbourhood of Halifax and Huddersfield, and generally known by the name of Yorkshire stone, are much used in Manchester, owing to their good colour and free working qualities. Many of our buildings in which these stones have been used show symptoms of decay, especially in the places where long pieces of stone have been required, and in mouldings and ornamental work.

In some cases the sulphuric acid in the atmosphere has acted on the clay in these stones, and an impure sulphate of alumina having been formed, it is washed by rain out of the stone, and the grains of silica in the latter soon crumble away. In other instances the water percolates down through the beds of the stone placed on its end until it reaches their bases, and then the frost in winter and the heat in summer expand the water and thus force off laminæ of stone, in addition to supplying acids to act on the stone as above-named.

The under ledges of coping stones, although the stone of which they are formed is placed in its proper bedding, often exhibit evidence of decay. This seems to arise from the moisture percolating the stone and finding its way to the lower parts, which, owing to their being shaded from the sun, are nearly always wet, and thus prepared for the action of frost and heat previously alluded to.

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It is surprising to find so small a variety of building stones having been used in Manchester as those above noticed, and it is to be desired that the architects and builders of our city should try other descriptions of stone when they can be had at a moderate price. It is difficult to say how the dolomitic limestones of the Permian group in Yorkshire, like those of Anston, would endure our climate and atmosphere, but so far as my experience goes no instances of them are to be found in our buildings. By the facilities which railways now afford, one might have expected that some of the beautiful syenite of Shap containing large crystals of felspar, or the grey syenite of Bootle and Ravenglass, would have made their appearance in Manchester, but to my knowledge none of them have been used. It is possible that they may not be known to our architects, but most probably the reason why the soft freestones of the coal measures are in such general use is that they are cheap and easily worked. My impression is, that cheapness is more looked at, both by architects and owners of buildings, in selecting stone than durability of character.

MR. BIDDER'S ADDRESS TO THE INSTITUTION OF CIVIL ENGINEERS.

THE following address was delivered by Mr. G. P. Bidder, on the 10th ult., being the first occasion of his taking the Presidential chair after his election:—

Gentlemen,—I beg to thank you for the distinguished position in which your suffrages have placed me. Looking back upon the eminent men who have successively occupied this chair, I cannot but feel anxious that the high character of our profession and the efficiency of this Institution should not suffer any abatement during the term of my tenure of office, and considering the powers and high professional position of my predecessors, this anxiety cannot but be increased; indeed it is only in one respect that I can hope to place myself on an equality with those eminent men,—that is by zeal for your progress, and the ardent desire I entertain of conducting our discussions with impartiality and courtesy towards all who may address you. On this I must act, and I am sure you will give me your cordial co-operation and assistance.

Before entering on the main objects of my address, I cannot but feel that it would be unbecoming in me not to allude to the recent loss of two of our most eminent brethren,—Mr. Brunel, and Mr. Robert Stephenson; although I am well aware I can add but little to what has been already written and spoken here and elsewhere, and in terms more eloquent than I can command.

With regard to Mr. Brunel, in common with you all, I ever admired the wonderful resources of his mind,—his extreme ingenuity,—his courage in facing difficulties of every description, and his great tact and resources in overcoming them, so long as he retained his physical power.

It has frequently been my lot to be placed in professional conflict with that gentleman, and I need hardly say that, in common with every other member of the profession, I found him a very dangerous and most able adversary; but at the same time he was equally high-minded, and above all mean and pettifogging practices for accomplishing his objects; he was one of those men in whose minds private friendship was never interrupted by professional strife; and there never was a time when if I needed it I should have hesitated to recur to him for advice, assistance, or sympathy; whilst in private life I can from personal knowledge attest his sympathy for distress, and his unhesitating generosity in pecuniary sacrifices to abate it. In his professional career, it appears to me that full justice has not been done to the memory of Mr. Brunel. I allude more especially to his exertions in accelerating the progress of oceanic steam navigation. The Great Western was a brilliant example of the correctness of his conceptions in this point. It must be conceded, that he was the first clearly and practically to conceive the advantages to be derived from augmenting the size of steamers, with a view to increased speed and to the extension of their voyages. Looking back therefore to the period of the construction of the Great Western steamer, she must be admitted to have been an absolutely successful experiment, mechanically and commercially, and the names of Brunel as the engineer, of Patterson as the shipwright, and of Maudslay and Field as the constructors of the engines, can never be omitted from the records of oceanic steam navigation. The next step was the Great Britain; and so far as regards the construction of the hull, the efficiency of that vessel even to the present day bears ample testimony to the skill of the design; whilst her having endured a whole winter's buffetting of the waves in Dundrum Bay, testifies to the strength of her construction, and to the powers of resistance of which iron vessels are susceptible. It must not be forgotten, that it was to this vessel that the screw-propeller was first applied on the large scale; and it should be stated, that by Mr. Brunel's exertions in experimenting upon the Archimedes the introduction of that mode of propulsion was greatly accelerated. The only part of this experiment which was not satisfactory was the performance of the engines; and this may be mainly attributed to the fact, that instead of confiding their construction to men whose lives had been directed to perfecting that particular branch of engineering, Mr. Brunel took upon himself the responsibility of designing the machines. It may not be unbecoming here to remark that genius, however great, cannot alone supply the results which can only be obtained by a life-long experience in practical details. It is deeply to be lamented that the life of our friend was not spared to consummate his conception of the Great Eastern steamship. This great experiment has been already partially discussed in this Institution, and there does not appear to be any reason why she should not be mechanically successful; but all who have had extended experience in our profession are aware that in all experiments there will arise certain phenomena, which no human foresight can anticipate. Now, seeing that the Great Eastern is six or seven times the bulk of any existing vessel, and seeing that this of necessity involved the application of two sets of engines, two kinds of motive power—the paddles and the screw-propeller—bearing also in mind, that she was intended to encounter head seas at a speed never hitherto contemplated, and knowing also the enormous forces which ordinary vessels have to withstand in heading the waves, however slowly, in heavy weather, it might reasonably be expected that in many respects her first trial would be somewhat disappointing. I sincerely hope, and I am sure that I carry your sympathies with me in trusting that there still remain in this country sufficient skill, enterprise, and co-operative action to bring this great experiment to a real test, and thus to complete the most fitting memorial to the fame of our deceased friend.

In alluding to Mr. Robert Stephenson, I cannnot but feel that I am scarcely in a position to take an impartial review of his career and of his character. For upwards of a quarter of a century I have enjoyed his most intimate, and I may add, his most affectionate friendship. Even this term is perhaps hardly strong enough,—for throughout the whole of this period his conduct towards me was that of an elder and affectionate brother—he has encouraged me in all he thought right, and has not failed to criticise all he deemed wrong, and had the necessity arisen he would have applied his whole fortune, to his last sixpence, for my benefit. I have said that our friendship has endured for upwards of twenty-five years, but our acquaintance extends over a much longer period, as we were in the same class and on the same benches at the University at Edinburgh. Probably no member of our profession, either past or present, ever availed himself more earnestly of varied opportunities of acquiring professional accomplishment than did Mr. Stephenson; his early youth passed with his father at Killingworth Colliery, his early manhood at Edinburgh, his engagements in the mines of South America; and on his return to England, his occupations in perfecting the locomotive, and in managing the works at Newcastle, his connection with the early railways, and added to all these his pursuit of the studies of chemistry and geology, which continued throughout his life, and even to within a few days of his decease, constituted a substratum of scientific and practical knowledge which few have obtained, and fewer still have the ability properly to apply.

One of the distinguishing characteristics of his professional career was, that however bold he was in the conception of an idea, as for instance the Britannia Tubular Bridge, yet no one with whom I ever came into contact watched with more anxiety the completion of these enterprises than did Mr. Stephenson; his mind was ever occupied in anticipating how and in what shape failures might arise, and no doubt it might appear to many that the precautions he took were often superfluous; but the experienced engineer knows well, that if he relies upon the chances turning up in his favour, without due precautions being taken, the enterprise is sure to be attended with some disasters; whilst the mere act of taking due precautions seems to have the effect

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of averting the consequences they are intended to guard against; in short the engineer is never justified in trusting to the favours of fortune whilst he has the means of guarding against her caprices. Another distinguishing feature in our late friend's career was his treatment of all those who were associated with him in his undertakings; his habit with those who enjoyed his confidence was to leave with them the utmost amount of responsibility which he could possibly lay upon them; and never to interfere except in cases of emergency, or where his moral influence was required to prevent undue interference from superior authorities;—the consequence has been, that over the whole face of the globe there are men of his school, who have risen to competency and to eminence, and who live to extol and respect the memory of their revered chief.

Of his successful professional career—his unbounded generosity—the liberality of his views, and the dignity and urbanity with which he filled this chair, you are all witnesses, and it will be long before the place is adequately filled which his decease has rendered vacant.

In approaching the subjects which ought to be considered the main object of this address, I would venture to remind you of the custom of our society, which is, that although we publish all that is said during the discussions and in the addresses of our presidents, yet it is always with the distinct understanding, that the remarks are not intended to represent the collective opinions of the Institution, but only of the individuals who utter them, and that they are not to be entitled to any more weight than the intrinsic value of the opinions themselves, or that which the position of the speaker may secure for them. I am well aware that even in my address I ought to make every statement without reference to personal convictions; but upon many subjects my opinions are so strong, that I cannot hope to escape developing the bias of my own mind. I trust therefore that this will be deemed excusable, bearing in mind the general understanding with regard to the transactions of this Institution.

It will be obvious to you all how great are the obstacles to giving novelty to each successive address of your presidents, and how increasingly difficult it is to render them interesting and instructive; it is not therefore my intention to advert to any of the topics which have been heretofore treated of on any of those occasions.

The steps in the progress of our profession, measured chronologically, are very unequal, as indeed is the case with all sciences, abstract or practical. When the mind of man is first released from thraldom and in the early stages of civilisation, it makes rapid and striking advances until a certain stage has been attained; indeed, the progress of the human mind in every branch of knowledge may be compared to the course of a stream emanating from a spring in some distant mountain recess; emerging into light, it pursues its course amidst rocks, through woods and over cataracts, affording abundant scope for the poet and the painter, and subsiding at last into the slow, gentle, majestic stream, pursuing its way through the lowlands, in its approach to the ocean;—such is the course of science; and although its latter stages do not present the vivid contrasts which accompany its early course, yet they are not less important nor less instructive; but the skill which is demanded to point out their effect and character is of a much higher order than is required to indicate the early phenomena. From this task, gentlemen, I shrink, with an innate conviction of my inability to treat the subject as I should desire. The object therefore of my address will be to allude to subjects which have not hitherto prominently occupied our attention or afforded ground for our discussions, with the express intention of inviting your consideration of them, and the design of securing their discussion at our meetings.

An objection may perhaps be raised, that I may be seeking to extend unduly the professional sphere of the Civil Engineer; but I have been long enough in the profession to see it grow from a mere craft or mystery into a scientific pursuit. This Institution, which may be regarded as representing the objects of the profession, now embraces among its members those who are engaged not only in the construction of roads, railways, harbours, &c., but of those also who are occupied in the construction of engines and machinery adaptable to every conceivable purpose, in the building of vessels, in the erection of gas and water works, in the laying down of electric telegraphs, and in the drainage of towns and rural districts;—in short, if I was now called upon to define the object and scope of the profession of the civil engineer, I should say that his particular province is to take up the results discovered by the abstract mathematician, the chemist, and the geologist, and to apply them practically for the commercial advantage of the world at large; and to diffuse their beneficent influences among all classes of his fellow-creatures.

Among the objects which appear principally to demand our present consideration are those questions most referable to hydraulic engineering. It is in this part of our professional study and practice, I am bound in candour to say, that the least satisfactory progress has been hitherto achieved, and upon these subjects the discussions in our society have been the most inconclusive. I believe that it is in a great degree owing to the fact of sound hydraulic knowledge being so little prevalent, that so many obstructions have arisen to the progress of public works. It is impossible otherwise to suppose that the errors which have been committed in the Health of Towns Commission would have occurred, or that a Blue Book outraging all the discoveries of science would have been published at the expense of government, had our profession been sufficiently alive to the subject. It is perhaps hardly fair to visit some of our public departments with the severity of criticism which has been applied to them by those to whom they may have been opposed, when it is considered how little unanimity of opinion prevails among ourselves on some important points connected with this subject; and it must be borne in mind, that the gentlemen in our public departments have nothing to gain in any way by sanctioning a scheme, however successful, whilst on the other hand, should injurious consequences result, they might be exposed to grave responsibility.

The points of the utmost importance upon which to arrive at a clear understanding are as to the relative effects of the scour upon our rivers and harbours, arising from the action of tidal or of land waters. I am free to admit, that I am one of those who attribute the smallest possible effect to the action of land waters, whilst I do attribute the most important effects to the action of tidal scour. This conviction has been forced upon me by a general view of our rivers and estuaries. Looking, for instance, to the river flowing past our doors—the river Thames. Can it be supposed that the mere driblet of water falling over Teddington-lock, even in seasons of the highest floods, can give any effectual aid to the tidal currents in preserving the channel from the sea to the Nore, and up to above Gravesend? Looking also to the fact, that when any great change or improvement has taken place in any of our rivers, we find them always to result from some new arrangement of the tidal currents—as for instance at Lynn, in the Clyde, and in many other cases; on the other hand, where has any marked result attended either the increase or the abstraction of the land waters? Upon the solution of this question depends the reclamation of large tracts of land now lying not only waste and absolutely useless, but in their present state exercising a most pernicious influence upon the population of the adjoining districts.

The time has arrived, when the effects of under-draining—now every year more actively pursued—upon the condition of your rivers, should receive most serious consideration. I recently adverted here to some anomalous results arising from under-draining, and showed, that in certain soils and under certain circumstances the effect of under-draining would be to pass less waters to the rivers than had previously flowed into them. If this view be correct, precautions should be taken to provide for the possible effects of an operation which is, otherwise, so rapidly augmenting the fertility of our soil.

Another feature in the drainage of towns demands attention; that is, the prevailing fashion of subverting the cesspool system, and of introducing out-fall sewers. One great inducement hitherto held out has been the prospect entertained of employing the sewage for fertilisation of the neighbouring land. Losing sight of the beneficent provisions of Nature for avoiding pestilence, it was assumed that the sewage of towns would necessarily be of a highly fertilising character; and it is mainly due to the exertions of our member, Mr. Hawksley, that this delusion has been to a great extent dispelled. Recent investigations have shown, that in towns amply supplied with water the sewage contains very little, if any, fertilising quality; certainly none of commercial value. Indeed a careful consideration of the economy of our rivers might have anticipated the conclusion. Look at the course of the Thames flowing through this great city,—consider the enormous population on its banks before it reaches the metropolis;—what would have been its condition had not running waters possessed that quality of self-purification which renders

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the sewage of towns of no practical value? I trust then that this session will not close without our having well considered the conditions under which a well-regulated cesspool system can be properly applied; and under what circumstances towns can be advantageously drained by out-fall sewers. Permit me here to express an individual opinion of what appears to me to be a useful application of the income arising from the bequest of the late Mr. Robert Stephenson. In due course the decision of the council upon its application will be announced; but in my individual opinion, instead of being divided into a number of small premiums, a considerable portion of it should be devoted in one premium, at fixed periods, to rewarding papers upon subjects recommended by the council, and which require the devotion of considerable time and labour; and it should be understood, that although the premium would be given for the best paper, it should be only awarded when the paper possessed the required amount of merit to entitle it to that distinction.

I would beg here to announce my intention of devoting, during this current session, the sum of £40, under the above conditions, for the best paper upon the subject of "the Regime of Rivers;" and I would suggest as examples to those who desire to devote their attention to this subject, the changes now taking place in the river Thames,—the condition of the Waveney and the Yare, at Yarmouth,—the harbour of Wells, as an example of the tidal scour alone sufficing to preserve the navigation,—the Ouse, at Lynn, relative to which so many records exist of the various operations executed there,—and the Tyne, and the Clyde;—but indeed, there is scarcely any river which, if critically examined, will not afford the most interesting and valuable experience. I need scarcely point out to you, that the works of Du Buat in extenso, and as abridged by Robison, with his elegant essay upon the history of rivers, combine the most ample, satisfactory, and interesting information on these questions.

There is another branch of the profession which is now becoming most important,—the extension of the Submarine Telegraph cables, by which our most remote possessions are being brought into almost immediate contact with the Home Government. The experience up to the present time has, however, been very unsatisfactory—whether we consider the condition of the cables laid across the Atlantic, or of several of those submerged in the Mediterranean, and as regards their duration after being laid down. It was the opinion of the late Mr. R. Stephenson, whilst presiding over the affairs of the Electric and International Telegraph Company, that a cable could not be anticipated to last more than ten years, and he therefore insisted on an annual provision being made for this decay. On the other hand, there are other companies possessing submarine cables who will not make any such provision. This anomalous state should not prevail in a commercial community such as ours. I have much pleasure in stating, that on this subject the government have taken a very judicious and liberal course, in which I am convinced the opinion of the country will support them. A commission has been appointed to investigate this question, with the most ample scope for their inquiries. Mr. Stephenson felt a great interest in this commission, of which I have the honour also to be a member;—since his decease the active duties have devolved upon our Associate Member, Captain Douglas Galton, of the Railway Department of the Board of Trade, and it gives me much pleasure to state, that from the indefatigable zeal which he devotes to this inquiry, information of the highest importance will become the common property of the country. The inquiry has for its object, not only the best form of cable to be laid at great depths in the ocean, but also the electrical condition when laid. It is, no doubt, owing to the want of such a preliminary inquiry that so large an amount of national capital has been wasted in such operations, and especially in laying that across the Atlantic. This subject will, I trust, receive your attention.

There are many questions which it appears to me we may discuss with advantage in connection with our National Defences. It may be contended that this subject scarcely comes within the strict limits of our professional pursuits; but seeing how important a part must devolve upon steam-vessels, upon our harbours generally, and especially those of refuge, upon the railway access to the coast, and upon our artillery, the preparation of which has now been admitted to have become part of the duties of our profession—inasmuch as the recent great improvements have been accomplished by Sir W. Armstrong, Mr. Whitworth, and Mr. Anderson, all civilians and members of our profession—I do not hesitate to advert to this subject, to which the public attention is so much attracted, especially as I do not know any other arena where such subjects can be so advantageously discussed as in this Institution. There is no assemblage which commands more general intelligence, and certainly none which contains so much mechanical knowledge. Applying our minds to this question, the first consideration is, what are the peculiar resources which England possesses, and what is most essential to be attained? As to our resources, they consist chiefly in our enormous and accumulating wealth—our boundless mechanical skill—and the genius to apply them. The object to be attained is the maritime supremacy of the narrow seas. We cannot indeed, like the continental nations, maintain large bodies of regular troops, nor have we like our neighbours a large reserve of seamen at command for emergencies. Before however applying these general considerations, I must advert to the fact of the small amount of novelty and of improvement in naval architecture which have originated in our own government dockyards, especially having regard to the enormous total expenditure recorded. It is the fashion to visit the shortcomings upon the statesmen in power; but in point of fact, they are as little in fault as we are who are sitting in this room. In a constitutional government, carried on through the agency of the House of Commons, the government has not the power of selecting the best mode of carrying on the public departments, but is compelled to adopt that which under the circumstances is exposed to the fewest disadvantages; having reference to the uncertain tenure of office, it is therefore unreasonable and useless to complain of statesmen; the more patriotic course is to suggest practical remedies. The main reason of so little improvement emanating from the public departments is the total want of that competition which exercises so irresistible an influence on all our commercial relations.

I cannot help thinking, that discussions at our meetings on many of the subjects within the scope of the public departments, will be reflected upon these departments, and will work for the general good. I repeat, why should not the skill, talent, and practical knowledge which has so rapidly improved our artillery, and has been resorted to by foreign governments for their navies, be rendered available for our national objects? The governments of Spain, Portugal, Sardinia, Austria, Turkey, and the Brazils, resort to our commercial shipwrights to form their navies, whilst Russia has recourse to the United States; the British government alone despising the resources offered by the native genius of the country.

As to our national defences, the all-important point is as before stated, the maritime supremacy of the narrow seas. It appears that for this object three conditions are essential:—

1st. That we should possess the fleetest boats for conveying intelligence, instructions, and information as to hostile movements;

2nd. The strongest, swiftest, and most powerful rams, or vessels for running down;

3rd. Armed ships of the most efficient description.

As to the fast despatch-boats, they are to be had in abundance from our commercial and mail services; especially such as those now constructing for the Holyhead and Kingstown line.

As regards the rams, there are many points demanding serious investigation. The first is, whether they should be constructed simply to act as rams, or be provided with an armament, and combine the two conditions? and thus, whether in attempting to combine both objects in one vessel, the actual efficiency of both may not be impaired! That is to say, whether giving to the ram its adequate strength may not interfere with its proper armament, and whether the provisions required for the armament may not defeat its object as a ram? It would appear to be obvious, that if a vessel were built solely for running down, and her sphere of action were restricted to the Channel, her form and the system of construction would not be essentially different from that which would be adopted if her operations were to be more extended. It must also be remembered, that the crew required to work her solely as a ram would be very small as compared with the additional number of men required to work a powerful armament—and upon the perilous service to which they would be applied we should risk but few lives, which cannot be replaced, in addition to the property which we can so easily re-establish;—and thus a powerful Channel fleet could be kept afloat at a small current charge. These are surely points of sufficient importance to demand careful discussion and development.

The points to be considered relative to the fighting ships are, whether they should not, like the rams, be specially constructed

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for service in the seas surrounding our coasts. Our men-of-war are now all constructed for carrying the British flag into distant seas, and for this purpose they are adequately masted and sparred to economise fuel on their passages to their destination. In a general engagement the spars and rigging not only require the special attention of a large part of the crew, but their destruction endangers the efficiency of the means of propulsion, and thus, on an emergency, not unfrequently leaves the vessel a helpless log at the mercy of the enemy.

Now if a special class of vessels was solely applied to the Channel service, there would not be any object in so fully equipping them, and in burdening them with such cumbersome top-hamper. Neither would such capacity be required for provisions, water, and fuel for long voyages. Under these circumstances, it is worth consideration, whether an entirely new class of vessels might not be constructed, with less draught of water, sharper lines, more power, greater speed, and heavier armament—all essential elements in future warfare—and thus secure for the nation a fleet of vessels strictly applicable to defensive purposes, which no other nation would have the means of opposing; and insure in future for this country that which it has hitherto possessed, the maritime supremacy of the narrow seas. Besides these points, there is the question of in what way the mechanical skill of the country and the constructive genius of commercial shipwrights shall be rendered available for the improvement of our national marine. It may be discussed whether the best course would not be, after defining the objects of any particular class of vessel required by the government, to solicit designs from the principal builders; and in furnishing such plans, the builders should not only state the cost at which they will build, but also the speed they will guarantee, combined with the capacity to carry the specified armament, in a manner to insure the efficiency of the vessel; the selections from these designs to devolve upon a commission of independent members. I again repeat that these may not be the best measures to be actually adopted, but their discussion within these walls must be productive of good.

Another branch of the subject is, the most facile method of concentrating forces upon those points accessible to an enemy. It has been suggested, that a littoral line of railway should be constructed. This proposition could only have emanated from those who were unacquainted with the physical features of our coasts. Shakespeare's Cliff, Beachy Head, the iron-bound coasts to the west of the Isle of Wight, are familiar to all. But in point of fact, looking to the existing railways, the problem admits of an easier solution than has been generally supposed. The South-Eastern, the East Kent, the South Coast, the South-Western with its branch to Dorchester and extension to Exeter, the Great Western, Bristol and Exeter, and the West Cornwall, the South Wales, and other railways, either directly approach every accessible spot on the coast, or admit of easy connection by branches. The only points remaining to be considered are, the defensive works at those places. This should be discussed. It is admitted that nothing can be more unsatisfactory than the state of the fortifications around our coasts. Lord Grey has graphically described those at Plymouth. A short railway journey, and a cruise down the Solent past the fortifications at Hurst Point, will prove that neither scientific investigations nor modern experience have, as yet, had any beneficial effect upon that department which charges itself with the control of such works.

As a natural sequence to the preceding subjects, we are led to the consideration of the proceedings which have taken place with regard to what are termed our Harbours of Refuge—as it must be obvious, that one main object of these works has reference to the operations of our naval forces—and I believe I am justified in observing, from what transpired during a recent discussion at this Institution, that neither mechanically nor financially can they be considered to be in a satisfactory position. According to the present system of conducting such works it is obvious that the principle of construction employed at Dover and at Alderney must necessarily restrict their adoption to a very limited extent. Whether we look to the time, or to the cost, the results are altogether inadequate to the sacrifices required. The protracted time is to a great extent owing to the system of voting the funds annually by driblets,—the result of which is, that neither the government nor parliament fairly appreciate at the commencement of a work the full extent of the responsibility involved, either as to time or cost. Can it be supposed that government or parliament, when adopting the recommendation of the commission to construct a harbour of refuge at Dover, imagined that the works would involve an actual cash outlay of five or six millions without interest, or of thirty or forty millions including interest, and that a hundred years at least would elapse before the full efficiency of the works would be secured; or that after an expenditure of nearly half a million sterling, and the lapse of upwards of ten years, the constructive resources of Great Britain would be exhibited to the foreigner landing at Dover, in the shape of an incomplete jetty with two incommodious landing-places? These and other results of a similar character may be fairly attributed to the system adopted, and must not be laid to the charge of any individual or department, and certainly not to the eminent statesmen who guide the helm of the nation for the time being; for in matters of this description they possess no interest, political or otherwise, apart from that of the country at large. No doubt one of the inconveniences of the present system is that of having to apply to parliament annually for grants,—the amounts of which, and the chance of obtaining them, depend upon the financial state of the country and the temper of the House of Commons, even although the period of the session may be selected when the government has the best command of the attendance in the House. No doubt that, having regard to these circumstances, the original plans of the works have often been conceived on a limited and narrow basis, adapted to the proposed expenditure, but totally inadequate to the objects supposed to be attained; the ultimate result generally being an extension of the design, an enlargement of the estimates, and a final completion of the works in a form or shape which defies investigation to affiliate. Thus money is wasted, time is sacrificed, and full efficiency is not attained.

The remedy for this defective state would appear to be, that antecedent to any application to parliament, the government should prepare full and detailed plans of the entire extent of the works intended to be executed, and obtain tenders from competent contractors for the execution, stating the time of completion and the terms and mode of payment. These plans should be deposited, at fixed periods, at the Private Bill Office, for the inspection of all who are interested. Thus, before the vote was taken there would be ample time for full criticism on all points, and though additional labour might be thrown upon the public departments in preparing the documents subjected to such investigation, the House of Commons and the members of the State would have the means of coming to the debate fully informed on all points connected with these national works.

In a financial point of view the gain would be considerable, because a work which is executed within a reasonable time is always more economical than one which is extended over an indefinite period; and also for direct financial considerations, which may thus be exemplified. Suppose a work estimated to cost a million is made to extend over twenty years, the outlay being restricted by the annual grant to fifty thousand pounds a year. The ultimate cost of this work to the country, supposing the government to raise the money at three per cent., involves an additional annual charge of about forty-two thousand pounds per annum—whereas, if the work was executed in five years by annual grants of two hundred thousand pounds a year, the annual charge to the country would only be thirty-three thousand pounds a year—thus, irrespective of all other advantages, saving nine thousand pounds a year. These observations only apply to works of real utility, and do not apply to undertakings of so useless a character that their execution cannot be too long protracted—such, for instance, as the pier at St. Catherine's, in Jersey, and others of a similar character.

I cannot but feel assured that, were the principle adopted which I have enunciated, the defects now admitted to exist in the harbours of Holyhead and of Alderney would have been avoided, and the Blue Book mystification at Portland respecting the expenditure upon the convicts employed on the breakwater works, would not have occurred, and the nation and parliament would have had the satisfaction of realising, on all these works, the full value of the outlay incurred. Ministers, by taking at once from parliament a grant for the full amount of the expenditure, would avoid the annoyance of the annual appeal, and the recurring waste of the public time in re-discussing all the features of these undertakings.

I have alluded here to certain defects which will always be inherent in the harbours of Holyhead and Alderney; both of which were, doubtless, originally projected on so limited a scale

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on account of the difficulty of obtaining parliamentary grants; but during the progress of the works their total inadequacy for the objects proposed became so obvious, that it would have been absolutely criminal to have persisted in the original designs: their extension therefore became a matter of necessity; but, alas! these extensions could only be carried out in such directions, that it is now admitted, that for the same amount of money the same extent of breakwater might have been constructed in a form much better calculated to resist the action of the seas, whilst affording more security and nearly twice the amount of accommodation.

Before concluding my address I cannot avoid contrasting the progress of government works with those undertaken by private enterprise. There is within a short distance an iron bridge, scarcely even partly completed, across the river Thames. There is no doubt that this bridge will be substantially and skilfully constructed, but it cannot be said to involve any feature of mechanical difficulty: it is constructed in London, and thus commands in respect of labour and materials the resources of the whole empire. Another iron bridge, spanning the river St. Lawrence, in Canada, is entirely completed and is opened for traffic: this bridge extends for nearly a mile and a half across a stream having a current varying from seven to ten miles an hour, it has to resist the pressure of ice accumulating, occasionally, to the depth of thirty or forty feet; the severity of the climate is such as to restrict the actual period of working to a few months in each year; the iron work and the great proportion of the skilled labour was derived from England; and a severe monetary crisis had also to be surmounted, which latter, however comparatively unimportant in government operations, exercises a formidable influence on private enterprise. Yet this entire work has been executed contemporaneously with the one uncompleted half of Westminster Bridge. Thus evidencing what the civil engineer can do when impelled by the pressure of private enterprise, as contrasted with his exertions when trammelled by the restrictions incidental to the conduct of government works.

Gentlemen, I am well aware that the observations I have made are open to the severest criticism. I have advisedly introduced into my address subjects and opinions of the most controversial character, because it is my design to induce upon them the fullest and freest discussion. I have endeavoured on the one hand, and I hope with success, to avoid subjects of trivial interest;—whilst on the other I have attempted to direct my remarks to subjects of national, commercial, and professional importance.

I have now been a member of this Institution for thirty-five years; during that period I have been a careful and anxious observer of its progress, and the result of my observations leads me to believe, that nothing has tended so much to the steady growth of this society as the animated discussions which so frequently occur within these walls. This point may however be also a subject of controversy; but, gentlemen, I have only one further remark to make,—upon which I can defy controversy,—that is, that all I have said within these walls, and that my conduct while occupying this chair, has been and will be inspired by the determination, so far as my humble powers permit, to perpetuate the prosperity of this Institution, and to maintain the reputation of the noble profession of which I am proud to be a member.

NEW LIFE BOAT.

The following is a description of a lifeboat, invented by Mr. Ludlam, of the United States, a model of which was recently exhibited at the Society of Arts, London:—

The invention provides this boat and others with hollow adjustable floats along their outer sides, and water-tight compartments within. The floats are made of a conical or egg form in their transverse section, and so fitted to the boat, as to secure their greater buoyancy when first touching the water. They are constructed of ten (more or less) canisters, of copper, india-rubber, in case of gunboats galvanised iron, or other material, arranged in a series, and terminating in elevated prows. Between the canisters are placed braces of wood or other material, of any desirable thickness, thus securing the floats from injury. The canisters are covered with wood, and are of such a shape as to be well protected by the gunwales. The floats are made adjustable, by their hinging or looping, from their upper edge, to the sides of the boat. They are fastened close under the boat's sides, or are turned outward and upward, by chains or ropes from their inner and outer sides, to hook above the boats; and should the boat be placed bottom upwards, she will, by a safe and simple contrivance, fold her "fins" or floats, from their extended position, close under her sides, right herself, and immediately extend them as before. A boat thus "winged" or "finned," it is said, will never swamp or capsize. The floats may be varied to suit the different style of boats to which they are attached. The boat, in the case of a self-righting and relieving one, is constructed after the general principles of such boats; with a sufficiency of shear from stem to stern, with high bulkheads, and with a deck over the bottom of the boat, so high that water within, pressing upon valves, will run through tubes passing through the boat's bottom. These valves are balanced into place by a lever turning upon a pivot, and are opened downwards by pressure of water from above. The deck, from the buoyancy of the floats, may be placed much lower than ordinarily, thus avoiding a "top-heavy boat" when loaded. The high bulkheads may be of special service by placing in their bottoms water tanks, opening through faucets into the boats, and filling through tubes from above. Into the bulkheads, above the tanks, are inserted valvular water-tight doors, thus creating lockers for the stowage of provisions, instruments, &c. They consist of an outer lid, hung and acting by a spring upon an inner lid, covered on its inner side with india-rubber, which is pressed against a rim around the edge of the door. These doors may also open to lockers along the sides of the boat.

ON THE APPLICATION OF SUPERHEATED STEAM IN MARINE ENGINES.*

By John Penn, President Inst. M.E.

(*With Engravings.*)

An opinion in favour of superheating the steam supplied to steam engines has long existed, and it has been maintained by many that important advantages might be obtained from this principle; though until recently but little has been effected in its practical application, and much doubt has been felt as to its advantages proving sufficient to lead to its general adoption. The development of the principle has probably been checked by exaggerated ideas being entertained respecting its advantages on the part of its earlier advocates; and also by somewhat incorrect views of the action of superheated steam leading to attempts to carry the superheating to an excessive degree, thereby involving much extra risk of failure and stoppage of the apparatus, and tending to discourage further pursuit of the object.

Superheated steam seems to have been definitely tried about 27 years ago by Mr. Thomas Howard, of Rotherhithe; but in this case the boiler or vaporiser was dry, and only enough water was injected at each stroke of the engine to supply the necessary quantity of steam. It would appear from the experiments made that very considerable economy was effected; but although the apparatus thoroughly established the principle, it was too delicate in its construction, and was for this reason given up. Mr. Howard appeared to be fully alive to all the advantages of the system, and always expressed his opinion that there was a loss of 30 per cent. in an ordinary steam engine, which would be recovered by superheating the steam. Soon afterwards the late Dr. Haycraft, of Greenwich, took up the subject and advocated it strongly, being convinced that great advantages would be obtained by superheating the steam in engines; and he used to express his confidence that the time would come when the principle would be generally adopted, and that a saving of 30 per cent. in the consumption of fuel would be thereby effected.

The importance of the principle was first impressed upon the writer many years ago by Mr. Howard, and afterwards by Dr. Haycraft, with both of whom he was very intimate; and he has become satisfied from the results of experiment and observation that important advantages in economy of fuel may be obtained from the system; the main question to be settled being, whether it involves any serious practical objection from complication of apparatus, risk of derangement and failure, or difficulty in lubrication of the engine. The recent trials he has made on a large scale have led him to the conclusions:—

That an advantage can be obtained from the use of superheated steam amounting to an economy of fuel from 20 to 30 per cent. in marine engines;

* Paper read at the Institution of Mechanical Engineers.

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That a moderate extent of superheating enables all the important advantages of the plan to be obtained;

And that apparently nothing objectionable is then necessarily involved from extra wear and tear, risk of failure, complication of apparatus, or difficulty in lubrication.

The real source of advantage in employing superheated steam appears to be in preventing the presence of any water in the cylinder of the engine, and insuring that the cylinder shall never be occupied by anything but pure steam; making it a real steam engine, instead of one working with a mixture of water and steam. In all condensing engines, the interior of the cylinder being open to the condenser during half the time of each revolution of the crank, is in communication during that time with the low temperature of the condenser, or about 110° when the vacuum is 13½ lb. per inch below the atmosphere, or 27 inches of mercury. There is consequently a rapid radiation of heat from the sides and end of the cylinder, cooling down the whole mass of metal. The steam admitted into the cylinder in the next stroke, at a temperature of 260° if at 20 lb. per square inch above the atmosphere, coming in contact with these cooled surfaces, heats them up again, being robbed thereby of a portion of its heat; and the consequence is the deposit of a quantity of water in the cylinder, from condensation of an amount of steam proportionate to the quantity of heat imparted to the metal of the cylinder. A portion of this water in the cylinder may be evaporated again into steam towards the end of the stroke, by carrying the expansion of the steam down to a sufficiently low pressure; but even then its effective value as steam in propelling the piston will have been lost during all the previous portion of the stroke. The engine must in fact be looked upon as only in degree better than Newcomen's atmospheric engine, in which the whole of the steam was condensed in the cylinder at each stroke; and the advantages of Watt's great invention of condensation in a separate vessel are not fully realised until this serious defect is removed. Now if as much heat be added to the steam by superheating it before entering the cylinder as will supply the amount of which it is robbed by the cylinder, it will remain perfect dry steam throughout the stroke, and not a drop of water will be deposited. This the writer believes to be the mode in which the superheating of steam acts in producing a saving of steam and consequent economy of fuel, by preventing the extensive waste of steam that ordinarily takes place: and this indicates the extent to which the superheating can be carried with any great advantage. The writer believes that an addition of 100° of heat to the temperature of the steam insures the accomplishment of the desired object with steam at 20 lb. per inch above the atmosphere, as used in marine engines; the steam is thus heated from 260° to a temperature of 360°, and is then only about as hot as the ordinary high-pressure steam of 120 lb. per inch used in locomotive engines.

The plan of superheating the steam before entering the cylinder is a simple and eligible mode of attaining the desired object, and appears also to be preferable to a steam jacket. For when the steam is supplied to the jacket from the same boiler as the cylinder, the supply of heat to the metal will be slower than in using superheated steam, owing to the difference of temperature being less; and to carry out the object fully requires the steam in the jacket to be superheated, and the cylinder covers to be also jacketed, since in the short-stroke marine engines, where the diameter is nearly double the length of stroke, the area of the two covers or ends equals that of the sides. But even then the application of the heat by the steam jacket is outside the cylinder, and the heat is delayed in its action by having to pass through the thick metal; whereas by the introduction of superheated steam into the interior of the cylinder the object is accomplished in the most direct manner, by heating the surface with which the steam comes in contact, and even a momentary chill of the steam down to the condensing point is entirely prevented. By superheating the steam with the waste heat of the smokebox, not otherwise usefully available, all this effect is obtained without cost; but with the steam jacket the heat used has to be supplied from the boiler. An important practical advantage attending the use of superheated steam is obviously that all objectionable joints for steam jackets are avoided; and the cylinder being felted and lagged the same as the steam jacket, there will be no more loss of heat by radiation from the outside.

The mode of superheating the steam may be varied in many ways: a general principle to be aimed at being to make use of the waste heat for this purpose after leaving the boiler, so as to accomplish the superheating without any cost of fuel; and to place the apparatus where it will not be exposed to injury from too great heat. The superheating apparatus has generally been placed in the smokebox or uptake flue in marine boilers, and has consisted of faggots of tubes or coils of pipe, for the purpose of obtaining the required extent of heating surface within a limited space.

The accompanying drawings, Figs. 1 and 2, Plate V., show the arrangement used by the writer, and employed in a recent extensive trial of the plan in the Valetta steamer of the Peninsular and Oriental Company, of 260 nominal horse power, running between Malta and Alexandria. In the smokebox AA, of each boiler are placed two horizontal faggots of tubes BB, forming the superheating apparatus, each consisting of 44 wrought-iron tubes 2 inches diameter inside and 6 ft. 3 in. long, placed in vertical rows, with clear spaces between them horizontally for allowing ready access in cleaning the boiler; these spaces are left opposite each row of tubes in a tubular boiler, but in the present case the boiler is constructed with Mr. Lamb's vertical flues in place of tubes. The superheating tubes BB, are fixed into the three flat chambers CCC, which are of wrought-iron welded up at the corners and closed each with a single flange joint. The steam is supplied from the boiler to the centre chamber through the stop valve and pipe D, and is taken off from the end chambers by the stop valves EE, communicating with the steam pipes FF, leading to the engines. The steam is thus made to pass through the superheating pipes on its way to the cylinders, and becomes superheated by taking up a portion of the waste heat escaping from the boiler flues before reaching the uptake flue G, leading to the chimney. The steam pipes FF, have also the ordinary direct communication with the boiler through the second stop valves HH, so that the whole superheating apparatus or either half of it can readily be shut off and disconnected at any time if desired.

The vessel has made two trips from Malta to Alexandria and back, a total distance of 3276 miles, with the superheating apparatus; and then two of the same trips without the apparatus, but with no other alteration. The result was a saving of 20 per cent. in the consumption of fuel, although the men were not experienced in the management of the apparatus; and there appears every reason to believe that when the apparatus has been a little longer time in use the saving will be still greater. The main object kept in view in the detail of construction of the apparatus was to insure a simple and durable plan that would not require any repairs for a long time; and for this purpose the superheating tubes were made a thorough mechanical fit, and free from strain of expansion tending to make them leaky. The wrought-iron tubes are three-sixteenths of an inch thick, and have thick ends welded on to them; these are turned down to a square shoulder, and all correctly to the same gauge for length, and fitted tight into the holes of the tube plate, which is also planed on the face and accurately bored; the tubes are then pressed into their places all at once by the plates being drawn together with screws, and are made steam-tight by the fit alone; the ends of the tubes are then expanded, as shown in Fig. 3. The total area of superheating surface, including the wrought-iron boxes, is 374 square feet in each of the two boilers, giving a proportion of 2¾ square feet of superheating surface per nominal horse power, the engines being of 260 nominal horse power, and the boilers having a heating surface of 19 square feet per nominal horse power: this proportion appears from the writer's trials to be sufficient for superheating the steam to the extent that is desirable. The apparatus has not leaked or failed in any way during the time it has been at work, and appears likely to prove very durable.

The heat employed for superheating the steam is taken entirely from the waste heat after leaving the boiler, which would otherwise have escaped by the chimney; and this abstraction of heat from the smoke-box, together with the screen of superheating tubes shielding the smoke-box doors, has produced a marked effect in keeping the stoke-hole uniformly much cooler when the superheating apparatus was applied than without it. The temperature of the steam is constantly indicated by a thermometer, which is fixed in a small cup projecting into the interior of the copper steam pipe, and containing a little mercury at the bottom, in which the bulb of the thermometer is immersed. The fluctuations of this thermometer indicate very delicately the variations in temperature of the steam; and the mercury in the thermometer is affected considerably by the changes in firing, falling when the firedoor is opened for fresh firing.

In this arrangement no additional space is required for the superheating apparatus, the whole being contained within the

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ordinary smoke-box, without any alteration of the boiler or any interference with its construction; the only external addition being the stop valves communicating with the apparatus. This apparatus can therefore be readily applied to ordinary marine boilers, without requiring any alteration beyond the extra connexion and stop valves, and without interfering with any of the arrangements of the engines or boilers; and the important saving of 20 to 30 per cent. of the fuel can be thus effected, without incurring any risk of trouble or delay from the superheating apparatus. In case of any failure of the apparatus, it will be seen that it is only necessary to shut one set of stop valves and open the other.

The writer would observe in conclusion that there are various plans adopted by different engineers for superheating the steam, many of which have been applied by the inventors, and in many cases with considerable success. Amongst these may be named those of Mr. Wethered, Mr. Partridge, and Mr. Pilgrim, who have done much lately to establish the value of the system by practical application.

In the *discussion* which followed,

Mr. Penn observed that the trial of superheated steam had been determined upon, in the case of the vessel described in the paper, after the completion of the boilers; and the time being very short for fitting up the apparatus, he had to devise a means of accomplishing it without interfering with the work already done, and had consequently adopted the plan shown, as the simplest arrangement and the quickest for construction. The apparatus was simply a work of repetition in the parts, the superheating tubes being all exactly alike, and fitted by machine work; the great object in view was to insure against any risk of interfering with the efficiency of the vessel by failure or accident with the new apparatus, and to arrange the whole so that it could be readily disconnected and the work carried on exactly the same as before the application of the superheating apparatus. He had not had an opportunity of trying any experiments with it himself, and did not consider the trial at present made a fully conclusive one as to results; but the vessel had been three months working since the apparatus was applied, part of the time without the apparatus for the purpose of comparison, and a pretty satisfactory proof of its success was that the engineers were very glad to get the apparatus in again; and there was found to be a reduction of 20 per cent. in the consumption of fuel when the apparatus was used. He had tried one approximate experiment with the apparatus before the vessel left this country, by graduating the opening of the injection cock of the condenser, and observing the extent of opening required for working with and without superheated steam; and he found that little more than two thirds of the quantity of injection water was required when the steam was superheated; showing that a much smaller quantity of steam must have passed through the cylinders into the condenser, with a corresponding saving in consumption of fuel in the boilers. A difficulty was anticipated at first in keeping the joints all permanently tight throughout the apparatus, but none whatever was experienced, and there had been no leak since it was put to work; the tubes were all made a thorough mechanical fit in the tube plates, so as to be perfectly steam-tight, and they were not exposed to any strains from expansion and contraction, as the end chambers were free to move with the tubes, and the whole was of one material. It was an important point in anything of the kind to have a thorough good job made at first, and several of the attempts at applying superheated steam had been unsuccessful from failure of the apparatus in mechanical points, causing objections to be felt to superheating that did not really apply to the principle itself, but only to defects in the mode of carrying it out.

Mr. W. S. Ward thought the paper that had been read was a most interesting one, showing a valuable example of carrying out an important principle judiciously and carefully. The importance of superheating the steam was pointed out by theory, which showed the great loss in the power ordinarily obtained from steam compared with its theoretical power; but it was often difficult to realise in practice theoretical advantages. As the quantity of latent heat taken up in evaporating water was a very large proportion of the whole heat supplied, it appeared more advantageous to apply further heat in superheating and expanding the steam than in evaporating more water; the ratio between the latent and the sensible heat being nearly 4 to 1. And in the case of expanding steam in a cylinder, a lowering of temperature was produced by part of the sensible heat in the steam becoming absorbed as latent heat for effecting the expansion of the steam; but if the steam were a little superheated originally, the extra heat would allow of the expansion being effected without cooling the steam below its natural temperature at the original pressure. He hoped this important subject of superheating steam would be carried on to a further extent, and that all the circumstances and laws of its action would be fully investigated.

Mr. H. W. Harman inquired whether there had been any opportunity of ascertaining what increase in volume of the steam was effected by the superheating, and whether there was any difference in the pressure; and whether the working of the boiler was at all effected by the superheating by any back action of heat being communicated to the steam in the boiler under any circumstances.

Mr. Penn replied that the pressure was kept the same, as it would be regulated in both cases by the load on the safety valves, which was not altered; the effect of the superheating could therefore be only to increase the volume of the steam by the expansion due to the increase of temperature, so that a greater quantity of steam at the same pressure would be supplied to the engines from the evaporation of the same quantity of water in the boilers.

Mr. J. F. Spencer remarked that a great difference sometimes existed in the temperature of the steam in different parts of the same boiler when superheated; he remembered noticing in the boilers of a large steamer, which had high steam domes, with the uptake flue passing up through so as to superheat the steam at that part, that the temperature of the steam in the top of the dome was as much as 340°, whilst it was only 260° in the boiler just below the dome.

Mr. E. A. Cowper observed that the pressure did not vary with the temperature; and whatever superheating took place, the effect could be only an increase in the volume of the steam and in its temperature, as it would be impossible for any difference of pressure to exist in the superheating apparatus, except indeed a slight diminution of pressure that would arise from the resistance of the small tubes to the passage of the steam. The first effect of the superheating would be the evaporation of all the moisture in the steam, as steam always left the water in a boiler in a more or less wet or damp state, from the mixture of minute particles of water with it, even when there was no sensible priming; it would then become perfect or dry steam, but at first would not be raised at all in temperature; but when the superheating was carried beyond that point, the temperature of the steam would be raised by all the heat added, and its volume proportionately increased, causing an increase in the total quantity of steam supplied at the same pressure and from the same evaporation of water. Steam was expanded by increase of temperature at pretty nearly the same rate as air and other gases: and since air at 32° was doubled in volume by an increase of temperature of 480°, steam at 20 lbs. per inch or 260° would be doubled in volume by 708° increase of temperature (480+260−32=708); and a rise of 100° from 260° to 360° would consequently increase its volume $\frac{1}{7}$th, causing an equal saving in consumption of fuel when the superheating was effected by using the waste heat of the smokebox. As the specific heat of steam was only about $\frac{3}{4}$ths that of air, steam would require only $\frac{3}{4}$ths the quantity of heat to be supplied to it to produce the same rise of temperature; and partly for this reason steam was now used instead of air in caloric engines, since the same effect of expansion was thereby obtained with so much less supply of heat. There was no doubt that in cylinders without steam jackets condensation of a portion of the steam took place at the beginning of the stroke, and a partial re-evaporation at the end, on account of the metal of the cylinder being colder than the fresh high-pressure steam entering from the boiler, but hotter than the expanded steam in the cylinder at the end of the stroke; since the whole metal of the cylinder could not change in temperature twice in each stroke, (though the interior surface must do so), the temperature of the cylinder and piston must be an average of the temperature of the whole of the steam coming in contact with them. He had tried a direct experiment suggested to him by Mr. Appold, namely, fixing a glass gauge tube in communication with the interior of the cylinder, the outer end of the tube being closed: at the beginning of the stroke the interior of the glass became quite dull with moisture, from condensation going on in the cylinder; but towards the end of the stroke the moisture was entirely evaporated and the glass became clear, showing that

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there was perfectly dry steam in the cylinder by that time. The cylinder was in fact a partial condenser at the beginning of the stroke, and a boiler at the end of a stroke; and if it were not for this boiling off of the condensed water at the end of the stroke, the cylinder would soon get very nearly to the temperature of the steam. In an expansion engine without a steam jacket he had found, by a comparison of the actual indicator figures with the theoretical figures which ought to have been obtained if no condensation had taken place in the cylinder, that the loss of power when cutting off the steam

At $\frac{3}{4}$	stroke amounted to a loss of		11·7 per cent.
At $\frac{1}{2}$	stroke	,,	19·6 per cent.
At $\frac{1}{3}$	stroke	,,	27·2 per cent.
At $\frac{1}{11}$	stroke	,,	44·5 per cent.

But when the cylinder had a steam jacket supplied with steam direct from the boiler, he found the actual indicator figure almost exactly corresponded with the theoretical figure, except that at the end of the stroke it was raised a little, about ½ lb. in pressure above the theoretical line, in consequence of the superheating of the expanded steam from the higher temperature of the metal of the cylinder. With steam in the jacket of the same pressure as that in the boiler he did not think there could be any condensation in the cylinder; for all that was requisite to prevent this was to keep up the metal of the cylinder at the temperature of the entering steam, by supplying the heat abstracted by exposure to the cooler steam during expansion, and that lost by radiation, which was very small in a well lagged cylinder: the piston ought to have non-conducting surfaces or plates, and the cylinder ends should have steam jackets. He was very glad the important subject of superheating steam had been so well taken up in the interesting paper that had been given by the president, and was confident that a still higher saving of fuel than the 20 per cent. mentioned in the paper would ultimately be effected by that means.

Mr. R. Morrison observed that the stop valves in the steam pipes of the superheating apparatus shown in the drawings gave the means of mixing the superheated and the ordinary steam, and he inquired whether any trial had been made of mixed steam in this case; also whether, if the boilers had not been already made before the addition of the superheating apparatus was contemplated, they might not have been made proportionately smaller, as the superheating apparatus formed in effect an addition of 2¾ square feet of heating surface per nominal horse power, increasing the original proportion of the boilers from 19 to 21¾ square feet per horse power.

Mr. Penn replied that the superheating apparatus must certainly be regarded as a portion of the heating surface, and some reduction might consequently be made in the boilers on that account, besides the reduction due to the saving effected in the quantity of water to be evaporated in doing the same work. In reference to the question of mixed steam, he had not tried any experiment on the subject, and did not see that as regarded the final effect it mattered how the steam was heated, provided the temperature of the whole steam that entered the cylinder was raised the 100° required to prevent any portion of it being cooled below its natural temperature whilst passing through the cylinder; and it seemed to him that the best way of attaining that object was to heat the whole steam on its passage to the cylinder.

Mr. R. Morrison asked whether any higher temperature had been tried, or was considered likely to produce a further advantage; also whether from the experience of the working of the present apparatus any smaller size of heating tubes would be considered preferable; and whether there was found to be any inconvenience in cleaning out the boiler tubes, on account of the superheating apparatus being fixed in front of them?

Mr. Penn replied that he had tried a temperature of only 360° to 370° at present, but from the results obtained his opinion was in favour of that temperature with the pressure of 20 lb. per inch that was used in marine engines, as accomplishing all the important portion of the saving to be obtained, and keeping quite clear of any risk of the increased wear in the cylinders and pistons to which they were exposed with higher temperatures. The size of the tubes used appeared to be satisfactory; and as the total area of steam passage had to be maintained, a smaller size of tubes would have involved a greater number of tubes and more workmanship, without perhaps giving any advantage. In the case of tubular boilers the superheating tubes were limited in size and arrangement by the tubes in the boiler, as they had to be placed in corresponding intermediate rows to allow of cleaning the boiler tubes, which could be readily done through the intermediate spaces.

In reply to a question as to what difference was shown by the indicator diagram in the expansion curve when the superheated steam was used, Mr. Penn stated the indicator diagram was fuller, the expansion curve not falling so rapidly at the commencement as when the steam was not superheated.—He had not tried the actual difference of temperature, but there was a very marked change in the temperature of the stoke-hole, which was kept much cooler than before.—No difference had yet been perceived in the wear of the engines with the use of the superheated steam; the results were of only three months' experience at present, but there was no probability of any effect being produced in that respect by so moderate a temperature as the one that had been adopted.

Mr. D. Adamson said he had used steam of 150 lb. per inch, which would be about 370° temperature, and found no cutting of the cylinder or injurious effect arising from the high temperature after 4 years' constant work, during which the piston had not been examined more than four times: the piston worked at a speed of 280 feet per minute, and had metallic packing, which continued quite smooth and in good working order. He recommended using high-pressure steam direct to a high-pressure cylinder, and exhausting after moderate expansion to a low-pressure condensing cylinder, heating the low-pressure steam up to the temperature of the high-pressure steam, say 370°, in the passage between the cylinders and in the second cylinder; thus deriving all the advantage of increase of bulk due to the superheating of the expanded steam, and of non-condensation between the cylinders; no difficulty being occasioned in the working of the piston from the high temperature in the second cylinder any more than in the first.

Mr. G. A. Everitt said he had made a trial of superheated steam in a pair of 60 horse power engines at his works in Birmingham, under the advice of Mr. Cowper, which had proved very satisfactory, and a decided saving of fuel was effected by the superheating, although it was applied to a limited extent and in only one of the engines, a condensing engine worked by the exhaust steam from the other engine; this steam was passed into an intermediate receiver, having a steam-jacket heated by the high-pressure steam from the boiler, so as to superheat the steam supplied to the condensing engine.

Mr. R. Morrison said he had made a trial of 60 lb. steam superheated to a temperature of 400°, in a condensing marine engine of 100 nominal horse power, expanding thro gh 5-6ths of the stroke; the cylinder had a 3-inch space round as a steam-jacket, supplied with the ordinary steam from the boiler, and a 2½-inch thickness of felt and wood lagging upon the steam-jacket. The indicator diagrams from the engines were very excellent, and almost identical with the theoretical expansion curve; but he thought the superheating had been carried rather too far, for the piston began to cut, and the oil was used up very rapidly in the cylinder.

Mr. E. A. Cowper considered that oil was not suitable for lubrication with highly superheated steam, as it was burnt up or charred rapidly at such high temperatures: 360° was certainly quite a safe temperature, and he thought even 400° might be made use of if oil were not employed for lubrication. He had known an instance where 100 lb. steam was used in a double-cylinder engine, expanded twelve times, and the high temperature of the 100 lb. steam (about 340°) was kept up in both steam-jackets; in that case there was found to be some cutting of the piston, but oil was used for lubrication. He had suggested a plan for preventing this by keeping the cylinders about 100° cooler than the steam, so as to cause a slight condensation upon the surface to keep it damp, and so prevent its cutting with the friction of the piston: he had tried an experiment which proved that even with very hot steam the surface could be kept damp if it were 100° lower than the temperature of the steam. The engines that had been referred to by Mr. Everitt were two of 60 horse power working at right angles: the first high-pressure, working with 35 lb. steam; and the second a condensing engine worked by the exhaust steam from the first; and as it was not convenient to alter the arrangement of the engines, he placed a large receiver between the two, more than equal to the capacity of the second cylinder, in order to reduce the back pressure in the first cylinder during the portion of the stroke that the second

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cylinder was not open to receive the exhaust steam, and the pressure of steam in the latter was also limited by a safety-valve on the receiver. This receiver was inclosed in a steam-jacket supplied direct from the boiler with a temperature of about 282°, and the average temperature of the steam in the receiver was 231°, so that the steam supplied to the condensing engine was to some extent superheated.

Mr. A. Fryer thought the full advantage of superheating would be obtained by simply carrying it so far as to insure that no condensation whatever should take place in the cylinder, and the steam should be in its natural state to the end of the stroke; for though there must be an advantage to be gained by carrying the process further, so as to have superheated steam acting throughout the stroke, thereby obtaining the additional supply of steam that was produced by its increase in volume arising from increase of temperature, yet he conceived that the fuel used to produce this effect would have produced a greater mechanical effect if applied to the boiler to generate more steam.

Mr. H. Maudslay considered the subject was one of great practical importance, and he was very glad it had been so ably taken up by the president; there was no doubt that an important economy of fuel would result from carrying out the principle judiciously. He had heard of experiments recently tried in one of the West India Mail Packet Company's steamers, at the suggestion of their engi eer, the late Mr. George Mills, in which about one-third of the steam was superheated about 30°, and then mixed with the remaining wet steam at the cylinder; the result was found to be beneficial, though much less marked than the results described in the present paper, where the whole of the steam was superheated. He was very glad to hear the present satisfactory results obtained by carrying out the plan of heating the whole steam in so complete and simple a manner. Failures had arisen in many previous attempts, where only a portion of the steam was heated, from too small an area of passage being given, sometimes only a single small pipe communicating with the steam chest, so that only a small proportion of the steam could pass through the superheating apparatus, and no sensible result could be obtained; many failures had also occurred from defects in the mechanical arrangement causing stoppages from leakage and burning of pipes and joints, which had occasioned doubts as to the practicability of carrying out the principle satisfactorily in work. He trusted the present successful application would be followed up by general attention to the subject, and a thorough trial of the principle to ascertain the best mode for its application and the extent to which it could be advantageously carried out.

Mr. B. Fothergill observed that in the use of superheated steam caution was requisite as to the effects of the high temperature, not only upon the working faces of the cylinders and valves, but upon the surface of the steam pipes when of iron; for he had known a case where superheated steam was tried in a mill in Manchester with decidedly good results as to economy of fuel; but probably from carrying the superheating beyond the point that had been recommended, so much oxidation of the pipes from overheating had occurred that the condensed water from the engine, which was employed for manufacturing purposes, became impregnated with rust, and spoiled a large quantity of goods.

Mr. J. F. Spencer thought the paper that had been read on the application of superheated steam was one of great value and importance, particularly on account of the thoroughly practical way in which the subject had been considered, and the excellent arrangement made for effecting the trial; avoiding all risk of carrying the process too far, and simply aiming at first at effecting the definite object of preventing any loss from condensation in the cylinder and insuring perfect steam throughout the stroke.

ANCIENT DOMESTIC ARCHITECTURE.

A rival to our Edinburgh and Quarterly Reviews of no inconsiderable power has sprung up in the one issued by Mr. Bentley, bearing his name: it has reached the termination of the second volume by the publication of its fourth number, and this, like its predecessors, is filled with essays upon subjects of the greatest interest, political, literary, and scientific; among those of the latter class we find an article bearing the title prefixed to this notice, and which will be read with much interest. It discusses with great ability the advantages obtained by the adaptation of English Gothic to the requirements of the age, over those of the Classic styles; and advocates strongly the claims of Mr. Scott to carry out his design for the new Foreign Offices, which unfortunately has been retarded by the insufficient reasons of Lord Palmerston. Had we space we should have been glad to copy into our pages the entire article; as it is we abstract that portion which gives a general view of the state of our civil architecture from the period when the Romans abandoned this island to the fifteenth century. On its perusal our readers will be desirous of a more extended acquaintance with the pages from which it is taken.

"But little is known of the state of England between the withdrawal of the Roman legions and the arrival of the Saxons. It may be taken for granted, however, that the existing domestic architecture of the towns was not wantonly or immediately changed. The arts probably suffered a universal decline. Buildings that fell into decay were repaired in an inferior manner. New buildings were constructed in a less and less intelligent imitation of existing models. The villages probably had never been anything better than assemblages of huts, and their condition was unaltered. The new invaders, we may be sure, found better accommodation in the Romano-British towns than they had left behind them. The Roman atrium, if it was still habitable or could be repaired, would become the hall in which the Saxon leader would feast his retainers, and would probably be the model for new buildings when required.

But as a fact the art of domestic architecture declined steadily during Saxon times. Many of the quarries known to have been worked by the Romans fell into disuse, and the carriage of stone became an impossibility as the great Roman roads for want of repair became more and more impassable. It would seem that even the more important Saxon buildings were constructed in timber, and thatched with reeds or straw, or roofed with wooden shingles. The hall of the Saxon thane was used by day as the common living-room of his followers, and by night as their common sleeping-place. The great man himself had generally a separate small chamber adjoining. Less dignified and less substantial than the dwelling of the thegne, the houses of a Saxon town can have been nothing but huts of mud or timber, of one story, and generally of one room. There is documentary evidence that down to the reign of Stephen the houses of London were of wood covered with thatch; and we know that many centuries afterwards, at the time of the Great Fire, the majority of the houses were still of wood and plaster.

It is clear that the stone architecture of the Saxons, when employed for domestic or military purposes, was nearly identical with that used for their greater churches. The drawings in contemporary manuscripts, though not to be wholly depended upon, are evidence of the use of columns, high roofs, crenellated walls, and floriated ironwork. But there were no chimneys, and the windows were mere narrow apertures, barred by iron stanchions, closed with wooden shutters, opening outwards and hinged horizontally at the top, glass being as yet unknown in domestic buildings, except (if we may so conclude from Bede's description of Wearmouth) in the cloisters and refectories of the greater monasteries. What we now call Saxon and Norman were, in fact, both varieties of the Romanesque, or debased Roman style. The change introduced after the Conquest was one of degree rather than of kind.

The manorial mansion of the twelfth century consisted of the 'hall,' with one or more adjacent chambers. The hall was either on the level of the ground, or raised upon a lower story or undercroft, which was half underground. In this, the only large room, the owner and his servants lived and took their meals; and the latter, at least, slept on its floor. The master at night occupied a small adjoining chamber. Even royal houses, as may be inferred from the exchequer accounts of the time of Henry II., contained merely the hall and the bedchamber, with the addition of a kitchen, larder, sewery, and cellar, to which however must be added the chapel, which was never absent in a royal residence. In the more important manors the hall was often of great size and dignity; sometimes even divided by piers and arcades of wood or stone into three parallel aisles, like the nave of a church, but more often an unbroken area of considerable dimensions.

But ordinary houses, not being manorial, did not of necessity contain this ample hall. The Jew's House at Lincoln, an example of the small urban dwelling-house of the twelfth century, is of two stories, the upper one containing the chief living-room. The staircase here seems to have been internal; but as often as not there was no communication between the two floors except by an external flight of steps.

The private room of the lord, called the solar or sollere—a word of uncertain derivation—forming a reception room by day and a bedroom by night, contained in this century the sole fireplace and chimney of the whole house. Very often instead of a chimney the smoke had an exit horizontally through the wall. The solar was generally on the first floor, raised upon a vaulted undercroft which was used as a storehouse or cellar. The exteriors of houses, even when of masonry, were often plastered and covered with polychromatic patterns. Miserable as such houses must seem to modern eyes, yet it must be remembered that the abundant use of hangings and curtains made the interiors a little less uncomfortable. With shutters and multiplied curtains draughts might be excluded at night from the small unglazed windows, which it must be remembered,

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were generally set as high as possible in the walls. Undoubtedly, however, the habits of the nation were then much hardier than they are now; and the upper classes must have endured in some respects the same exposure and hardship as are now the lot of those only whose houses consist but of two rooms, the living one being of necessity open to the air for the greater part of the day. It is probable also that both men and women of the highest ranks kept their heads covered even within doors all day long; a custom which is now confined to the very lowest classes. The furniture in this century was scanty, but—at least in the better sort of houses—not without elegance and comfort. Couches, beds, stools, and coffers are frequently represented in drawings and illuminations, and sometimes the ironwork employed in them is most delicate and beautiful. The floors were sometimes of wood, covered with rushes in winter and with newly-cut grass in summer.

An invaluable record, called the 'Assize of London,' made in the year 1189, the first of Richard I., gives us a very lively picture of the town houses of that period. Various privileges were granted to those who would replace their timber huts with buildings of stone, roofed with tiles. The law of party-walls and of windows was defined; and—which is especially remarkable—careful provision was made for furnishing each house with its *camera privata* and cesspool. It may be gathered that the houses were generally of two rooms and two floors, the lower of stone, used for a shop or rather for a warehouse, and the upper one, called emphatically *domus*, 'the house' of wood. An ordinance issued in the reign of King John, after a serious fire in 1212, renews the former regulations, and distinguishes between the *domus* and the bedroom. In illustration of this, in the north of England the kitchen used to be called the 'house-place,' the place where the family and servants used to live in common. We may correct this by saying that the 'house-place'—a term still used in the midland and northern counties—is distinguished from the kitchen on the one hand, and the 'parlour' if there be one, which is not common, on the other. At best these London houses were not so good as a modern labourer's cottage: they were to be whitewashed within and without, even over the thatched roofs, where tiles or lead were not used, as a protection from fire. Each alderman had a hook and cord with which to pull them down bodily, when it might be necessary to stop a conflagration. Each house also was to have a tub of water before the door.

The existing remains of the domestic architecture of the twelfth century are but few, and are too often miserably mutilated.....and many most interesting fragments of ancient domestic architecture are, when you come to examine them with a practical eye, very small and inconvenient. The great hall was often spacious enough; but the smaller chambers were small indeed. This is what strikes every observer in going over a mediæval house. Hence we must make a very considerable deduction from the effect of so picturesque a view of the interior of the chamber of a château of this twelfth century, as is given by M. Viollet le Duc, in his 'Dictionnaire du Mobilier Français.' There we see a bedroom, at least—to judge by the relative proportions of the furniture—14 feet high and 30 feet broad, a size which we may safely say was seldom or never reached at that epoch. The roof is of massive timbers, borne on blocks of solid masonry. The walls are painted to represent ashlar. The windows, narrow Romanesque lights, are glazed and curtained. A huge stone chimney projects into the room between them, and a fire blazes on the andirons. A couch, a bed with curtains, a table, a bench, a stool, and a wardrobe, with curtains, pillows, a hanging lamp, sconces, and a triptych, make a very dignified and imposing whole, which however is probably more ingenious and clever than truthful. The accomplished French antiquary has authority, we do not doubt, for each item of his picture; but the ensemble is deceptive, through this arbitrary enlargement of scale.

We advance now to the thirteenth century, corresponding roughly with the great transition from the Norman Romanesque style to what has been best called the First Pointed. The long reign of Henry III. was distinguished by great architectural progress, the king himself having been a constant patron and diligent student of the art. In this century, moreover, social progress encouraged architectural changes. Castles, for instance, became less exclusively intended for purposes of defence. The domestic element modified the military one. Manor houses and granges increased in number as the security of the country became greater.

There was, however, no great difference of plan in the houses now built from that of the preceding age. The great hall was still the chief feature; but to the solar there were often added one or more adjacent chambers. In particular it may be observed that every bedroom had now its *garderobe*—euphemistically so called. It is curious to observe that our ancestors so early reached a point of refinement in this matter, which was quite lost in subsequent generations. These indispensable adjuncts of a house are now beginning to be well planned in modern buildings, and at least to be sufficient in number. But, as every one knows, in a house of the last century no suitable provision was ever made, and even in mansions of great pretensions their owners have often been at their wits' end to introduce such chambers which were never contemplated in the original design. Any one who has visited Strathfieldsaye, for example, will remember the ingenuity with which the great Duke of Wellington's determination to provide each suite of rooms with this accommodation has been carried out.

It would appear that in this century the solar often attained considerable dimensions in important houses, and was divided by screens or partitions into several chambers. The windows of the solar also began to be provided with glass casements as well as shutters. Glass was still too costly for use in the great hall and the inferior rooms; and the casements, made to fit the windows in the several solars of the various manor-houses, were carried about from place to place when the family migrated from one house to another. It must be borne in mind that in these days the monarchs and the great lords, spiritual or temporal, moved about from one manor to another, not as now from the mere dictates of pleasure or duty, but from sheer necessity. As the country then was, with bad roads and ill-supplied markets, it was not possible to feed in any one place continuously the vast number of retainers which it was the pride of every great man to keep up. Accordingly the household lived at each manor in turn till its produce was consumed: and then it was time to go somewhere else. It is this fact that explains the great number of changes of abode which we read of in mediæval histories, and the extraordinary number of palaces or houses that were kept up by royal personages or archbishops or mitred abbats in those times. Henry III. had no less than thirty-eight royal mansions. The migration from manor to manor must have been oftentimes troublesome enough, when the party had to carry with it its furniture, its 'chapel,' and even the glass casements for the windows. Thus in 1265, Simon de Montfort, Earl of Leicester, travelled with a train of one hundred and sixty-two horses to visit his wife at Wallingford Castle: and when he arrived there it is mentioned that there were three hundred and thirty-four horses in the stable. The outbuildings of a large house must therefore have been very extensive. But it is certain that, while the hall and the chief apartments were of stone, the stables and attendants' rooms and even the kitchens were often mere temporary structures, like sheds, erected near the more substantial buildings. Besides the more frequent use of glass, it must be noticed that chimneys became common for the first time in this century. The kitchens, which were often of great height, had generally louvre-boards in their upper part; and the hall was usually warmed by a fire in a brazier in the middle. Most probably charcoal and not mere wood was used for this fire, as it still is in the great hall of Trinity College, Cambridge, which is, we believe, the last remaining example of the mediæval practice. The louvre over the middle of the roof, as in the last mentioned fine example, was for the purpose of permitting the escape of the smoke or fumes.

The internal fittings of houses in this century became far more finished and beautiful than they had been before. Wainscoting for walls became not uncommon, generally painted in patterns or subjects. The use of rich and costly hangings continued. Moveable and fixed screens are frequently spoken of, and the doors were covered with drapery fixed on spurs or canopies. Wooden floors were common in upper chambers, and tiles began to take the place of merely levelled and rammed-down earth in the great halls. Now, too, we begin to find records of drains and cloacæ, and for the first time we read of the supply of water in towns by means of conduits.

As to the furniture of this century it would seem that there was no great improvement upon that of the preceding age. The stools and forms were still of the stiffest and most formal kind, and the beds were laid on benches. But cushions and mattresses and bolsters were abundant, and were ornamented in a very luxurious manner. The tables were still moveable, that is, planks laid upon tressels. Spoons were now common, but forks had only just begun to make their appearance at the royal table.

It is curious to compare, again, with these facts the imaginary sketch given by M. Viollet le Duc of a French interior of this same century. The idea of presenting to the faithful eyes of his readers these pictorial summaries of his inquiries is most felicitous. Here, then, we have a very spacious chamber, with two large windows, each of two square-headed lights, opening as casements. They are protected by shutters and curtains. In the window-sills there are cushioned seats. The bed stands on a platform; is curtained round from a framework which is suspended from the roof, and is sheltered from the draughts from the windows by a rich carved screen like the parclose of a church. On one side there is a chair of state with a canopy, and some coffers or lockers, serving as seats, are placed about the room, besides a metal faldstool, and a 'pew' or high-backed bench by the fire. The chimneypiece is of carved stone, and projects boldly into the room, richly adorned with statuary. The roof is panelled, and the walls are tapestried under an elaborate cornice. A small carpet is spread near the fire. In this ingenious sketch we do not dispute the accuracy of most of the particular features, whether of the architecture or the furniture; for existing remains, and contemporary drawings, fully vouch them. But we doubt whether these details were ever combined in so commodious an apartment; and we suspect that the windows in this century were never so large or so well glazed: while the floors, we know, were rude in the extreme; and carpets were still an unheard-of luxury.

The London of the thirteenth century was still made up of wooden huts of two stories, while even then Paris was beginning to be remarkable for

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its street architecture. Matthew Paris, describing the visit of Henry III. to the French capital in 1254, says expressly of the king that he 'consideravit elegantiam domorum, quæ de gipso, videlicet plastro, fiunt in civitate Parisiaca, et mansiones tricameratas, et quatuor etiam stationum vel amplius.' Such houses, of three chambers and four stories or more, were certainly a contrast to the two-roomed and two-staged whitewashed hovels of his own capital. On the other hand, London had already begun to have foot pavement in all the principal streets. There were no inns as yet, and travellers had to carry their own provisions or to depend upon the hospitality of the monasteries. Hospitality, as is well known, was a very heavy and constant charge upon monastic revenues.

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The Liberate Rolls, preserved in the Record Office, contain an invaluable series of facts bearing on the domestic architecture of the long reign of Henry III. Here may be found the king's minute directions for the works required in his numerous mansions. At one time he orders some wainscoting or other to be painted green. his favourite colour, or 'histories' to be painted, or touched up. At another time, windows are to be fitted more closely with shutters, or to be glazed; or new ones to be pierced in dark rooms. Here a garderobe is to be made, and there a chapel of wood and thatch is to be replaced by one of stone, with an oriel or gallery, in the upper part, for the queen's use, so that she might enter it from her own chamber. The king seems to have been particularly anxious that the queen should be able to go to chapel 'with a dry foot,' and he commands, over and over again, that a pent-house or cloister should be made from door to door when the two buildings happened to be distinct.

We now reach the reign of the first Edward, a very important epoch in the history of English art. Whether the second age of the Gothic style, the Middle Pointed or Decorated, was an indigenous invention of our insular architects, or whether its first germs were imported from France, large provinces of which were at this time subject to the English crown, is a point that has never been satisfactorily settled. But it is certain that this mature Gothic—this culminating period of the development of the Pointed style—was nowhere handled with greater freedom and mastery than in this country. The domestic architecture of this century kept pace with the improvement of the ecclesiastical manner; and, with the growth of refinement, the plans of houses were now modified from the earlier type so as to cover a larger area, and to include a greater number of chambers and offices.

England in the fourteenth century was so comparatively peaceful at least in the more settled districts, that the country houses of this period become less and less fortified, or in other words, more and more like dwelling-houses instead of castles. But the towns were still chiefly built of timber, and few town houses of this age therefore still survive. Fortunately for our purpose the reverse is true of the contemporaneous architecture of the English provinces of Guienne and Aquitaine. There the times were too disturbed for the wealthier classes to betake themselves to the country. Consequently they congregated for mutual protection in the towns, which grew proportionably in importance, and above all, in architectural dignity. Many of these towns, called *bastides* in the Provençal dialect, still remain in extraordinary preservation. They were for the most part planned by Edward I., who founded Hull and Winchelsea in his insular dominions on the same principles. And we may safely conclude that the civic architecture of this country would have very nearly resembled that of the French provinces, had it been necessary, or possible, to substitute stone buildings for the timber structures of which our then existing towns were mainly composed.

To the fourteenth century we owe, it would seem, the parallelogrammatic arrangement of house which is still the one most usually adopted where space is too important to be wasted. This compact plan, making what is now called a self-contained house, is a step in advance from the older arrangement of a hall with its solar attached. But the latter plan still held its ground in most places. Wings, however, were now more frequently added, with bedrooms and other chambers; and the solar and its accompanying rooms were often made in the form of a tower. Sometimes, also, the stables and offices and gatehouses were so planned as to form, together with the mansion, a complete quadrangle; the whole, as in the beautiful example of the Mote at Ightham, in Kent, inclosed within a moated line of defence. In more exposed districts, such as the Welsh marches or the border counties, all granges and manor houses are of necessity strongly fortified. In the north, the Pele towers (as they are called) were a favourite form of house; and very often in that part of England there were no buildings beyond the tower itself, the latter being generally a solid structure of three stories, with a vaulted and loop-holed ground story, and the living-rooms above, approached by a staircase pierced in the thickness of the wall. But in less exposed neighbourhoods a country house, though never left quite undefended, was often merely provided with a single strong fortified tower, in which, on occasions of danger, the family might take refuge till help came. Long after other kinds of fortification had fallen into disuse, the practice of surrounding the house with a moat continued. It was not till the time of Elizabeth that the moat itself was generally dispensed with, though it had already become a well-established fact that the near proximity of a body of stagnant water was prejudicial to health. It is stated that the moat at Hurstmonceaux was drained off in the reign of Elizabeth for sanitary reasons, since which time it has been preserved as a dry ditch. The recent historian of Swyncombe, Mr. Napier, quotes a passage from Burton's 'Anatomy of Melancholy' on this subject. 'Some discommend moated houses,' says that writer, 'as unwholesome. So Camden saith of Ewelme, that it was therefore unfrequented; ob stagni vicini halitus, and all such places as be near lakes or rivers.' Of course all the sewerage of the house was drained into the moat, and the consequent filthiness can scarcely be imagined by those who have not seen the now rare spectacle of a still used moat laid dry for purposes of repair.

Illuminated manuscripts of this age represent the domestic architecture of the time with more minuteness and general accuracy than in preceding centuries. In towns the gable ends of all the houses faced the street, and were enriched with bargeboards and crockets; and often with the corbie-steps still so common in many continental cities. The chimneys were generally cylindrical, and the roofs made of tiles or shingles. It was still common to use colour on the external walls, either in imitation of masonry or in patterns incised upon the plaster. The Round Tower at Windsor was—as we know from the accounts of Adam de Hertyngdon, anno 39 Edward III.—painted all over externally, and was therefore called La Rose. It is supposed that its outer walls were diapered throughout with this flower.

No marked difference in the treatment and furniture of the great hall itself was introduced in the fourteenth century. It was still the general living-room of the collective household: entered by the screens at the kitchen end, with side tables in its length, a fire in the middle, and a dais or high table at the upper end. The solar or private room of the heads of the family was at this end, generally raised on a story which served as a cellar. From the solar, one or more windows revealed all that passed in the hall to the master's eye. This general arrangement continues to this day in college halls; and in some of them, as in Trinity College, Cambridge, the head of the house has still a private window from his own 'lodge,' through which he may survey the hall. This at any rate was open and straightforward. But what is to be said of the curious examples existing at Great Chatfield, Wiltshire, in which these peepholes are concealed in the form of stone masks or corbels, through the pierced eyes and mouths of which a full view could be had of all that passed in the hall? The floor was still generally unpaved. A gallery, for minstrels or any other purpose, often occupied the lower end. The domestic windows of this period are scarcely distinguishable from those used in churches, except by the depression of the sill, so as to form a kind of window-seat, and by the frequent introduction of a transome. We should add however, that still as in the former age, the casements were generally moveable, as may often be seen upon close examination of the rebates of the interior section of the jambs and monials. Below the transomes the openings were closed with wooden shutters and iron stanchions. It was only in churches that glass windows were as yet fixtures; and Longland, in his 'Piers Plowman's Crede,' describing the luxury of the hall of a Dominican convent, says that it was furnished

'With wyndowes of glas wroughte as a chirche.'

It was a common arrangement to divide the chapel into two floors in its nave or western part, while its eastern sanctuary was as high as the building. It would seem that these two western rooms, which often had fireplaces in them, were not exclusively used for devotional purposes. Sometimes the solar itself served as the place of domestic worship. A shutter was opened in a window communicating with the sanctuary; and through this the family could hear mass from their own apartment. This upper chamber over the west end of a domestic chapel was generally called an 'oriel.'.....The name oriel might naturally be transferred from the window to the chamber in which it occurred, just as in modern houses it is very common to hear a particular chamber, in which there is a bay window, described as 'the oriel room.' Such an upper chapel, in fact, closely resembles the royal pew or gallery in St. George's Chapel, Windsor, or that very curious little projecting gallery in the old conventual fragment of St. Bartholemew's, Smithfield. These are in point of fact nothing but oriels projecting internally into the church; and we do not doubt that the constructional arrangement of the upper floor of a domestic chapel was exactly similar.

We are enabled, by the romances of the period, to fix the exact time when the progress of refinement first began to make it usual for the lord and lady to take their meals in their own chamber away from the general meal in the common hall. The custom first introduced was to use the solar, which, be it remembered, was also the bedroom, for their private meals; but after a time it became usual to have a separate dining-room. This of course was at first considered exclusive, and an unpopular innovation. Thus we read in 'Piers Plowman':—

'Elenge is the hal every day in the weke,
There the lorde ne the lady lyketh not to sytte,
Now hath eche ryche a rule to eaten by himselfe,
In a privée parlor, for poore mens sake,
Or in a chambre wyth a chimney, and leave the chief hal.'

In the fourteenth century it first became common to provide separate bedchambers for the chief guests or other members of the family. Carpets however, though coming slowly into use, had not superseded rushes and straw—sometimes mixed with green leaves and fragrant herbs—for the floors. It is less generally known that many a fourteenth-century house

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was provided with a regular bath-room, the water being laid on through a conduit, which also supplied a lavatory. Bathing-tube of large dimensions, covered by an embroidered hanging, are also represented in contemporary illuminations. Connected with this are the garderobes, as to which a valuable hint might be taken by modern builders from such an example as that of Langley Castle, Northumberland, where a whole tower is devoted to these necessary adjuncts of a dwelling-house. One consequence of the necessity of consuming upon each estate in turn the produce of its farms was that each manor house was obliged to supply conveniences for all the necessary processes of preparing food. At every such house, therefore, there were at least a granary, a bakehouse, a brewery, and a slaughter-house. So that the offices, although as we have seen very often constructed of wood and plaster, were always very extensive. The kitchen, when it was built of stone, was always a most picturesque structure; often of a quadrangular or octagonal plan, connected with the hall by a covered passage, and roofed with a lofty louvre."

(To be continued.)

INSTITUTION OF CIVIL ENGINEERS.

Dec. 13, 1859.—JOSEPH LOCKE, Esq., M.P., President, in the chair.

Annual General Meeting.

The Report of the Council for the past session, which was read, noticed briefly, in accordance with the usual practice, some of the works in progress or which had been completed during the preceding twelve months.

Commencing at home, the state of the works for the main drainage of the metropolis, under Mr. J. W. Bazalgette, was first described. Attention was then directed to the progress in improving the railway communications of the metropolis, including the Metropolitan railway, and the Victoria station and Pimlico railway, both under Mr. Fowler; the Charing Cross railway, under Mr. Hawkshaw; and the Twickenham and Kingston branch railway, under Mr. Errington.

Among the lines recently completed in England were mentioned the Portsmouth and the Manchester and Crewe railways, both executed under Messrs. Locke and Errington; also branches from the South Staffordshire railway to Cannock, Norton, Tipton, and Darleston, and, in the Lake District, the Coniston railway, under Mr. McClean, and Mr. F. R. Stileman. The Severn Valley railway, under Mr. Fowler, and the extension lines to the West of England, in connection with the South Western system, under Mr. Errington, were also alluded to.

Passing to Docks and Harbours, the extension works of the Grand Surrey Docks, under the joint charge of Mr. Bidder and Mr. Joseph Jennings, were described. An outline was then given of works of this class recently completed under the direction of Mr. Abernethy, including the new docks at Swansea, a dock at Newport, a pier at Silloth, on the Solway Frith, where there was also a dock, and a pier and breakwater at Blyth. In all these cases hydraulic machinery, constructed by Sir W. Armstrong and Co., was employed for working the coal drops, lifts, dock gates, cranes, &c. At Penarth, near Cardiff, the conversion of the river Ely into a tidal harbour, and the construction of a dock there, with a railway to connect it with the Taff Vale line, had been carried out by Mr. Hawkshaw, and Mr. S. Dobson. At the Southampton Docks, extensive works had been completed by Mr. Giles; and at Southport, an iron pier by Mr. Brunlees. The Norfolk Estuary works had also been progressing under the care of Sir John Rennie and Mr. Fowler; whilst at Eastbourne waterworks had been completed by Messrs. McClean and Stileman.

In Scotland, the inauguration by Her Majesty the Queen of the Glasgow Waterworks, executed under Mr. J. F. Bateman, was commented upon; and it was stated that in the west the Castle Douglas and Dumfries railway had been lately opened, whilst the works on the Portpatrick railway, under Messrs. B. and E. Blyth, were advancing.

The railway system of Ireland had received considerable development. The lines from Longford to Sligo, Athenry to Tuam, Newry to Armagh, and to Warren Point, and Dungannon to Omagh, under Mr. Hemans; as well as those from Athlone to Roscommon, and from thence to Castlereagh and Castlebar, ultimately to be extended to Westport, Ballina, and Boyle, under Mr. Fowler and Mr. Fred. Barry; and from Athlone to Tullamore, Killarney to Tralee, Mallow to Fermoy, under Mr. Le Fanu, with some others of less importance, had been pressed actively forward. At Londonderry, the bridge now being built over the Foyle, under Mr. Hawkshaw, to carry both a railway and a roadway, was noticed. The selection of Galway as the port for the Atlantic steamers to America was also alluded to. The completion of a graving dock for ocean steamers at the mouth of the Liffey, near Dublin, under Mr. G. Halpin, was likewise referred to, as well as of the Cork Waterworks, under Sir John Benson.

Important lines of Submarine Electric Telegraphs had recently been successfully laid. The cable for the Red Sea line, from Suez to Aden, which had been manufactured by Messrs. Newall and Co., had been submerged under the superintendence of Mr. Lionel Gisborne, the electrical arrangements having been carried out by Messrs. Siemens, Halske and Co. This line was now being extended from Aden to Kurrachee. Other lines between Constantinople and the Greek Islands had been laid by Messrs. Newall and Siemens, and it was stated that but for a defect in a cable lately submerged between Candia and Alexandria, India would probably have been telegraphically connected with the mother country before the end of the present year.

A great step had been gained in the transit to the East, by the opening of the entire Egyptian railway, between Alexandria and Suez, including the extensive wrought-iron bridge across the Nile at Kafr Zyat. This work was executed by Messrs. R. Stephenson and Co., and Mr. H. Grissell, under the immediate superintendence in this country of Mr. G. R. Stephenson; and was fixed by Mr. E. Price, under the direction of Mr. Henry James Rouse, the chief engineer to H. H. Said Pacha.

It appeared from a return made to an order of the House of Commons that the Indian government had guaranteed about forty-one millions sterling, for the construction of public works, principally railways, in that empire. The amount of the guarantee was, in nearly all cases, 5 per cent. Several of these undertakings had been alluded to in previous reports, but a statement was given of the progress made up to the present time. On the East Indian railway, to which Mr. Meadows Rendel was the engineer-in-chief, and Mr. Turnbull the acting engineer in India, 45 miles had been opened between Burdwan and the river More, and it was thought that in the next year the Ganges would be reached, at Rajmahal. The line between Allahabad and Cawnpore, 126 miles in length, was in full operation—and beyond, as far as Agra, it only awaited the arrival of the materials for the permanent way. Other portions of the line were proceeding with a rapidity hitherto unknown. Of the Great Indian Peninsula railway, to which Mr. G. Berkley was the engineer-in-chief, and Mr. J. I. Berkley the acting engineer in India, 195 miles had been opened. A further length of 50 miles was nearly finished, and an additional 50 miles would be completed by Midsummer next. There were now under contract 785 miles, the entire system embracing lines to the extent of 1100 miles in length. The Madras Railway, of which Mr. Hawkshaw was the engineer-in-chief, and Mr. J. M. Heppel the chief resident engineer, had been opened to Goriattam, 96 miles from Madras, the eastern terminus. By the end of the year it was hoped that it would be completed to Salem, a further distance of 110 miles, or about half-way to Beypoor, the western terminus. Probably by the end of 1861, the whole of the main (south-west) line, 405 miles in length, would be opened, when there would be a through communication by railway across the peninsula, between the Coromandel and the Malabar coasts. In Scinde and the north-west provinces of India the railway between Kurrachee and Kotree, the steam service upon the river Indus, and the Punjaub system of railways connecting Mooltan with Lahore, Umritsir, and Delhi, were making rapid progress under the direction of Mr. T. A. Yarrow, and the immediate superintendence of Mr. John Brunton in Scinde, and Mr. W. Brunton in the Punjaub. Measures were being taken for prosecuting the works on the Eastern Bengal Railway, until his decease in the hands of the late Mr. Brunel, but now transferred to Mr. Hawkshaw; on the Great Southern of India, under Mr. G. B. Bruce; and on the Calcutta and South-Eastern, under Mr. J. A. Longridge.

During the present year, the first steps had been taken in an enterprise which promised to rival even the Grand Trunk railways in magnitude and importance; this was the establishment of the Madras Irrigation and Canal Company, for the construction of canals of irrigation and transit throughout the Madras Presidency, and the adjoining states, and ultimately in other parts of India. The engineer-in-chief of this undertaking was Colonel J. T. Smith, M.E.

The extensive iron pier now being erected at Madras by Mr. F. Johnson, was also briefly described.

A survey of the island of Mauritius, made, at the instance of the colonial government, by Mr. J. A. Longridge, during the last winter, had shown the great local benefits which the railway system would confer on that colony.

Turning to the continent of Europe, the railway system in Spain was analysed. During the present year the great line from Madrid to Alicante with a branch to Valencia, had been opened throughout. Other branches of this line were in progress to Toledo, and to Ciudad Rodrigo. There were also in course of construction two grand lines from Madrid towards France; 1st, the Northern of Spain, which proceeded by the Escorial, Valladolid, Burgos, Miranda and Vitoria, to Alsasua; 2nd, the north-eastern route, by Guadalajara, Zaragoza, Tudela, Tafalla, and Pamplona to Alsasua, where it joined the northern of Spain; and from whence a common line was to traverse the Cantabrian Pyrenees to Villafranca, and onward by Tolosa St. Sebastian, and Passages to Yrun, on the frontier of France, only 20 miles from where the French lines at present terminated. Great exertions were also making on the line between Barcelona and Zaragoza. The Biscayan railway, from the port of Bilbao to Miranda, on the Ebro, and thence along the right branch of the river to near Tudela, was in course of construction by Messrs. Brassey, Paxton and Wythes, under Mr. Vignoles. It was stated that the Spanish government appeared to be anxious to push the extension of railways throughout the peninsula, offering subventions as an inducement; but the interference of the government in all the details of construction was a great drawback to the introduction of English capital, and to the satisfactory progress of the works.

In Italy, Piedmont, Austria, Prussia and Holland, but little seemed

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to have been done; while in Sweden and Norway the railways were slowly but steadily extending.

At Copenhagen water and gas works had been recently constructed under the superintendence of Mr. Simpson; and a large tract of land had been recovered from the harbour and a dry dock constructed by Mr. A. Giles. The project of Mr. Murray, to extend the harbour southward, by cutting a channel through Kallebod Strand, between the islands of Amager and Zealand, had recently received the sanction of the Danish legislature.

The English system of waterworks appeared to be making considerable progress abroad. During the past year works for the supply of Altona, from the Elbe, at a distance of eight miles, had been constructed by Mr. Hawksley, who had also commenced other works, in conjunction with local engineers, for the supply of the cities of Stockholm, in Sweden, and Bridgetown, in Barbadoes.

In Russia, the Riga and Dunaberg railway was progressing under Mr. Hawkshaw, and was expected to be completed early in 1861.

In the Brazils, four commercial cities on the sea-board had been selected as the starting points of railways to proceed into the interior, viz., Recife or Pernambuco, Bahia, Rio de Janeiro, and Santos. The first section of the Don Pedro Segundo Railway, at Rio de Janeiro, had been constructed by Mr. E. Price. The works on the Pernambuco Railway were being vigorously prosecuted under Mr. Gregory and Mr. Peniston; a section, 19 miles in length, was opened in February 1858, and the second section would it was expected be completed in the summer of the next year. The Bahia Railway, which was 80 miles in length, was under the direction of Mr. Vignoles, and the immediate superintendence of Mr. Hutton Vignoles, the contract for the works having been taken by Mr. John Watson. The first section would probably be finished by Midsummer 1860, and the entire line in 1863. Both the Pernambuco and the Bahia railways were designed to terminate, ultimately, at the river San Francisco, about 300 miles from the mouth, at or near the point where navigation ceased. The surveys and explorations for the railway from Santos, better known as the San Paulo line, had been made under the direction of Mr. Brunlees, by Mr. Fox. Several hundred miles of macadamized roads had been laid out by Mr. Hutton Vignoles, through the province of Bahia, partly in connection with the railway. These were fast approaching to completion by Mr. Watson as contractor. The works of the Mangarratiba Serra road had been carried out by Mr. E. B. Webb. The hydraulic works in front of the city of Rio de Janeiro were progressing under Mr. C. Neate; and Mr. Law had undertaken the construction of the docks there. Gas works had been established at Rio de Janeiro, and at Pernambuco, and were in contemplation for Bahia. Mr. C. B. Lane was the engineer-in-chief to the home government at Rio, and Mr. W. Martineau was the government engineer at Pernambuco.

The principal papers read during the session were then noticed; and it was remarked, that though comparatively few in number, they were in excellence and in variety of subjects treated quite equal to those of former years. This was evident from the interesting and animated discussions to which they gave rise, occupying about one-half of the entire number of meetings.

The members were again urged to make the institution the depository of copies of any public or private reports upon which they might have been engaged, so as to be at hand for reference. The council had pleasure in announcing, that Mr. George Robert Stephenson had expressed the intention of presenting the portrait, by Briggs, of the late Mr. George Stephenson;—that Messrs. Isambard and Henry Brunel had kindly offered a portrait, by Horsley, of their late lamented father;—and that Mr. Joseph Cubitt had promised the portrait, by Boxall, of Sir William Cubitt, past president. It was hoped that these valuable additions to the collection already upon the walls in the meeting room, would induce further contributions, so that the series might be rendered complete.

The deceases of the members during the year were announced to have been:—the Earl De Grey, honorary member; Messrs. Isambard Kingdom Brunel, Hugh Ebrington Fortescue, William Hartree, Daniel Mackain, Robert Stephenson, M.P., Thomas Storey, and Alexander Wright, members; James Barrett, Samuel Bennett, Robert Cantwell, George Donaldson, Robert Barlow Gardiner, Edward Highton, John Houldsworth, Edward Hughes, and George Mills, associates. The resignations of one member and three associates were announced; and it was stated that the effective increase during the year (after deducting the deceases and resignations) amounted to thirty-seven, whilst the total number of members of all classes on the books was eight hundred and ninety-four.

It was felt that the loss of two such men as I. K. Brunel and Robert Stephenson could not be adequately estimated. Both had been prematurely removed in the prime of life, and in the vigour of their intellect,—the former, on the eve of the completion of one of his gigantic and original conceptions, after successfully combatting great difficulties in the execution of many peculiar constructions;—and the other, when it might have been hoped that the practical experience of many years in the prosecution of great and successful works would have been rendered useful to his country in the House of Commons, and as an adviser of the government, for which he was eminently qualified, not only by his knowledge, but by the uprightness of his character.

Among other munificent legacies to public bodies, Mr. Robert Stephenson had bequeathed to the Institution of Civil Engineers the sum of two thousand pounds. It would be for the succeeding council to propose the mode of appropriating the interest of this fund in such a manner as to connect the name of Stephenson permanently with the institution.

The financial position of the institution continued to be very satisfactory. There was an available balance of £1356, (of which £1000 was on deposit at interest,) being an excess of £300 above the balance of the previous year.

The series of Minutes of Proceedings up to and including the volume for 1857-58, had been completed, by the publication of Vol. viii. Part 2, and of Vol. xvii. It was stated that the Minutes for the past session would be issued early in 1860.

The council, in resigning their trust, thanked the members for the support accorded to them on all occasions; and asked for their successors the same kind co-operation they had experienced,—without which the institution could not continue to make the progress that had up to the present time marked its career.

After the reading of the Report, Telford Medals were presented to Messrs. M. Scott, R. Mallet, H. Bessemer, and W. J. Kingsbury; a Watt Medal to Mr. J. W. Jameson; Council Premiums of Books to Messrs. T. S. Isaac and M. B. Jackson; and the Manby Premium, in Books, to Mr. W. J. Kingsbury.

The thanks of the institution were unanimously voted to the officers of the institution.

The following gentlemen were elected to fill the several offices on the Council for the ensuing year:—G. P. Bidder, president; J. Fowler, C. H. Gregory, J. Hawkshaw, and J. R. McClean, vice-presidents; Sir William Armstrong, J. Cubitt, J. E. Errington, T. E. Harrison, T. Hawksley, G. W. Hemans, J. Murray, J. S. Russell, G. R. Stephenson, and J. Whitworth, members; and W. Bird and Capt. Huish, associates.

SUGGESTIONS FOR A NEW FORM OF FLOATING LIGHT-SHIP.

By Alfred Fryer.

Authorities agree that ordinary floating-lights are uncertain, being liable to be drifted from their moorings; they are also frequently injured by storms, and are expensive to maintain.

As the violent action of wind and waves on a considerable surface is the chief cause of mischief, it is proposed to construct a vessel presenting little surface exposed to their influence. The form proposed somewhat resembles a hydrometer, and the material used is wrought-iron, the "stem" being surmounted by the lightroom and lantern, and the "bulb" containing the dwelling apartments and store room. The form of the stem is slightly taper, and at its union with the lightroom is only of sufficient width to admit a ladder and the body of a man easily. The length, shape, and strength would vary within certain limits by local considerations. The vessel represented in the diagram and model was 125 feet long, two-thirds being exposed and one-third submerged. A wide flange, the office of which was to retard and reduce oscillation and vertical motion, was attached to the widest part of the "bulb." The discomfort of living 20 feet below the surface of the water was shown to be small. Some little light could be reflected down the "stem," while quiescence when the water was violently agitated by storms, immunity from the dangers of fire and lightning, and little or no chance of shipwreck or being drifted from the moorings, are advantages not to be forgotten. Ample ventilation could be secured by dividing the stem into ventilating shafts.

Moderate cost, steadiness during storms, and the great elevation at which the light is exhibited, are the chief advantages.

It is proposed to construct lighthouses, in all cases where it is important that mariners should estimate their *distance*, as double lights. The lower light should be exposed in the same tower at a given distance, say 50 feet, and by measuring the apparent distance of the lights apart, either approximately with the eye or accurately with a sextant, the distance can be at once determined.

If Mr. Herbert's proposition for mooring a series of floating-lights along the English and other channels should be adopted, it is proposed to unite them with each other and with the shore by means of a submerged cable and electric telegraph, so that important information either respecting the lighthouses or vessels in distress can be communicated to head quarters without delay.

[Models of the ordinary form and proposed new form of light-ships were exhibited during the reading of the paper, at a recent meeting of the Literary and Philosophical Society; and on the surface of the water being agitated the motion of the former was considerable, while that of the latter was very slight.]

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INSTITUTION OF NAVAL ARCHITECTS.

A meeting for the purpose of establishing an institution of naval architects was held at the Society of Arts on the 10th ult. This institution has been in course of formation for some months past, and has met with great support. The following is the substance of an explanatory statement which was made to the meeting by the secretary:

"The want of an institution which should have for its exclusive object the improvement of ships, and of all that specially appertains to them, has long been felt by many professional men. Indeed for some years past this want has been a subject of conversation among such persons, and many of those now present have doubtless heard it frequently deplored. But the utter failure of all previous attempts to establish such an institution seems to have cast so black a shadow of distrust before every newly-conceived project of a like nature, that until very recently no one has been found confident enough to hope for success in such an undertaking. Early last year, however, when the Royal Navy was a subject of much anxiety to the public, and when it was felt that if the establishment of such an institution was ever to be effected that was the right time to set about it, the matter was again revived. Without, at this stage of our proceedings, entering into any minute statements, I may say that several gentlemen, some of them without and some within her Majesty's service, took up the subject, quite independently of each other at first, and resolved to bring about, if possible, the result which is now before us in the present meeting. It was from the first felt that for such an institution as that which we contemplate to be successful, it must be directed towards what I have before designated the improvement of ships and of all that specially appertains to them. No institution which should have for its object only the improvement of the forms of ships, or of the actual building of ships, or of the fittings of ships, or indeed of any single branch of the naval architect's study, could ever be successful; because, in the first place, there is not a sufficient number of persons to constitute an effective institution engaged in any one branch; and secondly, because no single feature or portion of a ship can be properly studied apart from others. Hence it was seen that the scope of the institution must of necessity be wide enough to embrace the consideration of all that is part of, or belongs specially to, a ship. This being so, it was felt that the naval architect—to whom alone the ship as a great complex whole is a subject of study—was the only proper person to give designation and character to the society; and consequently it was decided that naval architects should constitute the body, and that its title should be the 'Institution of Naval Architects.' But naval architects alone do not produce ships. With them must be associated—and closely associated, too—the shipbuilder, the man of science, the seaman, the engineer, the mast-maker, the rigger, the sail-maker, the smith, and others, or no ship could ever be built and equipped. Hence it was concluded that for the institution of naval architects to become a vital and vitalising body it must draw into association with itself persons from all such classes. This it is proposed to do by the establishment of the class of Associates—a class which it is believed will become very numerous, and will render most invaluable aid to the institution. In consideration of the great advantages which will doubtless be derived from the associates, it has been thought right to give them a share in the governing council of the institution, and accordingly, while the council had been mainly nominated from among naval architects (as it doubtless should be), a few seats have been opened to eminent naval officers, engineers, and other gentlemen. With the same view, and in order to secure the greatest possible amount of influence for the institution, it has been thought desirable to solicit the services of a number of noblemen and gentlemen of great ability and eminence, who are or have been closely connected with either the royal or mercantile navies, and who might be willing to act as vice-presidents. It is hoped that in course of time the institution will exert a beneficial influence upon those great and ever-changing fleets on which we, as a nation, are so much accustomed to rely; and that this hope is shared by those who are most competent to judge of the matter is proved by the list of the vice-presidents who have thus far accepted office. In view of the national interests likely to be advanced by the institution, it was likewise thought better to waive the idea of a professional president, and to prevail, if possible, upon his grace the Duke of Northumberland—who has been First Lord of the Admiralty, has for long taken a most deep and generous interest in the system of coast lifeboats, and is also an eminent officer of her Majesty's navy—to accept the office. Although his grace has not yet accepted the presidentship, it is hoped that a new appeal to him may be attended with success. In conclusion, I will very briefly recapitulate our proposed objects, and mention our contemplated modes of operation. The objects of the Institution of Naval Architects are wholly comprised under three heads:—First, the bringing together those results of experience which so many shipbuilders, marine engineers, naval officers, yachtsmen, and others are acquiring, quite independently of each other, in various parts of the country, and which, though almost valueless while unconnected, will doubtless tend much to improve our navies when brought together in the printed transactions of the institution. Secondly, the carrying out by the collective agency of the institution of such experimental and other inquiries as may be deemed essential to the promotion of the science and art of shipbuilding, but are of too great magnitude for private persons to undertake individually. Thirdly, the examination of new inventions, and the investigation of those professional questions which often arise and are left undecided because no public body to which professional reference can be made now exists. The means by which it is proposed that the first of these objects shall be effected consists of the reading and discussion of papers at periodical meetings of the institution, the exhibitions of drawings and models, the publication of reports of the proceedings of the institution, and the establishment of a professional library and museum. The means by which the second object is to be effected will of necessity vary with the nature of the inquiries to be instituted. The objects embraced under the third head will be carried out either by the council or by special committees appointed by it."

ON HEATING BY STOVES AND BY OPEN FIRE-GRATES.*

By Arthur Findlater.

In his paper "On an Improved Stove for Heating Apartments," &c.,† Dr. Stark brought out prominently the well established fact, that when air is heated in any manner, no matter what, its capacity for containing vapour is increased. Air at 32° for instance can contain only as much vapour as would sustain ·2 or $\frac{1}{5}$ inch of the barometer; at 60° its capacity is increased to ·523 or $\frac{1}{2}$ inch; and at 80° it is as high as 1 inch. Therefore in winter, when air at freezing enters a room, and is heated to 60° or 70°, without any water or moist objects being present, it acquires a thirstiness, as it were, to satisfy this increased capacity; and in this condition it abstracts the moisture from the skin and lungs in a manner so ravenous and forcible, as to be seriously injurious. One chief cause at least of the disagreeable feeling caused by stove-heated air is this excessive thirstiness; and a leading feature in Dr. Stark's contrivance was a remedy for this evil.

But in the conversation that followed the reading of the paper, a pertinent question was put by a member present: Why, namely, the air in a room heated by a stove should feel drier than that in a room heated by an open fire? The air, be it observed, is supposed to enter both rooms in the same condition, and both are supposed to be heated to the same degree; that is, so as to produce the sensation of sufficient warmth. If increase of temperature, then, is the sole cause of the thirstiness, why should it not be equal in both cases? That it is not so is a generally admitted fact. Every one's sensations tell him that there is a difference in the degree of dryness. There may be other differences between the two cases, but this one is unmistakeable.

In the conversation alluded to, various explanations were offered of this fact; but none I believe were felt to be satisfactory, even by those who offered them. The following solution of the difficulty occurred to me at the time, but not in a sufficiently clear form for being enunciated; and I take the liberty of now bringing it before the society, in the hope that some member who has the necessary apparatus, and is more accustomed than I am to making observations of the kind, may be induced to put it to the test.

Dr. Stark went so far towards what appears to me to be the true explanation of the difficulty, by observing, that with an

* Paper read at the Royal Scottish Society of Arts.
† See *Journal*, vol. xxii. p. 308.

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open fire the air in a room is more frequently renewed, owing to the copious draught of the chimney; and that the fresh air constantly entering prevents the thirstiness from being so much felt. But this explanation is liable to the objection, that it just amounts to saying, that with an open fire the air is changed before it has time to become thirsty; that is, before it has time to become warmed in any considerable degree;—for it comes in the end to that. The supposition however is, that the room is warmed to the necessary degree, that is to the same degree as is thought necessary with a stove; and how can this be, if the air is changed before it has time to become as warm in the one case as in the other?

My object is to reconcile this apparent contradiction—to show how two apartments warmed, the one with a stove the other with an open fire, may have the same general temperature, that is, may both give the same sensation of warmth to the living body, and affect the thermometer to the same extent; and yet that the air in the room with the open fire may, and in fact must, be colder than the air of the stove-warmed room.

The end to be attained in warming apartments is not to give heat to the body, but to prevent the body from losing its own heat too rapidly. Suppose, first, a person in a room that is without any artificial warmth, and at a natural summer temperature of 60°. The body is in such circumstances losing heat at a certain rate, but a rate at which it can constantly repair the loss as it occurs. The heat thus parted with is lost in two ways; part is given off in *radiation*, part is abstracted by *convection*, or the carrying power of the air; in other words, by the film of air in contact with the body becoming heated and ascending, and thus making room for other films to do the same. We may assume that the portions of heat lost in these two ways are about equal; observations made expressly to ascertain the point lead, I believe, to this conclusion. In the case we have supposed of a room without artificial heating, the air and the floor, walls and furniture, are all of the same temperature. But suppose now that from some cause, no matter what, the solid objects in the room receive a temperature of 70°; the return radiation from these is now stronger than it was, and the body loses less heat by this one of the two channels of loss. In order then to restore the balance, and make the whole loss the same as before, the temperature of the air would require to be proportionally reduced—say to 50°.

Now, in this supposed case we have, as appears to me, precisely the conditions established in a room by an open fire. An open fire acts almost solely by radiation; and radiated heat has little effect on the air. The rays of a bright fire may be sufficiently strong to scorch the hand at the distance of several feet, and yet the intervening air be as low as 40° or 50°. The rays of the fire strike on the floor, walls and other objects, and heat them; and it is by contact with these that the air receives what heat it gets from an open fire. This however is a rather slow process; and as the air is being constantly removed, its temperature can never rise within a good many degrees of that of the solid objects.

In a stove-heated room the case is the very opposite. The radiation of a stove is comparatively feeble. A high heat is not admissible, owing to the disagreeable and unwholesome odours it causes; and radiation diminishes in intensity, not in proportion as the temperature diminishes, but in a much higher ratio—as the square, it is generally assumed. Although, therefore, the radiation of a stove is not without effect, it is little compared with that of an open fire. If a stove had no effect on the floors and walls of a room but through its direct rays, it would affect them but feebly indeed. It makes up however for this by its direct effect on the air through contact. If the stove is at 212°, a constant current is ascending from it at a temperature of 100° or upwards, and, mixing with the rest of the atmosphere of the room, soon raises the whole to perhaps 80°. This heated atmosphere now acts on the walls and solid objects; but being rare, and a bad conductor, air takes a long time to impart much heat to a solid—as is well known to those who have to warm churches by heated air. In frosty weather a stone building may be filled with air at 80°, and yet continue for hours to feel as cold as a well. For the heat given off by the living body is absorbed by the ice-cold walls, which give back but little in return.

In a common sitting-room then, warmed by a stove, the dispersion of heat by conduction to the outside is sufficient to keep the walls and solid subjects considerably below the temperature of the air in the room, and thus it becomes necessary that the air should be kept at a comparatively high temperature—say 70°—in order that the whole effect on the living body may be the same as that of a uniform summer temperature of 60°. Need we wonder then that a stove-heated room should feel dry compared with a grate-heated room, seeing the air in the former is probably at 70°, and that in the other only 50°: a difference of temperature that gives a difference in capacity for moisture of ·729—·373= ·356 inch.

There is another point to which I would call attention for a moment. Is the superior agreeableness of an open fire owing solely to the air being less dry? I apprehend not. If the above speculation has any truth in it, is it not evident that there must be a very different set of heat-sensations in the one case as compared with the other? In a stove-heated room the body is as it were in a warm, or at least in a tepid bath, and receives but little heat from radiation. In the presence of an open fire, on the other hand, the sensations from radiation are comparatively strong, while the immediate contact of the air is cold. I apprehend that the bracing influence of this cold-air bath, conjoined with the titillation of direct rays of heat, gives a more pleasant sensation, and has a more stimulating effect on the nerves and on the vital processes generally, than the opposite conditions. I am not prepared to say exactly *why* it should be so; but it seems to be in analogy with several other facts in physiology to believe that such is the case.

I have to confess, in conclusion, that the suggestions now thrown out are as yet only speculation. I have had neither apparatus nor opportunity to put the theory to the test of experiment. But if any one with the means at command should think it worth while to try, the question I believe would not be difficult to settle. In each of two rooms warmed on the two plans, let there be one thermometer exposed in the same manner as the person is to all the thermal influences that are operating; and another thermometer, surrounded on all sides by shields of bright tin, so as to protect it completely from radiation, and yet allow the air free access; and while the exposed thermometer stands at the same height in both rooms, I feel pretty confident that the shielded thermometer in the stove-room will show a temperature a marked degree above the shielded thermometer in the room with the open fire.

REVIEWS.

A Treatise on Optics. By S. Parkinson, B.D., Fellow and Tutor of St. John's College, Cambridge.

On the general laws of Optical Instruments. By J. C. Maxwell.

It is a humiliating consideration for mathematicians, that mathematical analysis, although professing to be, as it undoubtedly is, the key to all the exact sciences, is often incapable of penetrating much farther than the portal which it has unlocked, and leaves the rich contents beyond to be explored by experiment and empiricism. Astronomy is the only science which mathematics can claim as solely and exclusively her own conquest: even in mechanics, including of course practical engineering, much that is known to be true is in vain sought to be *proved* to be so; and many facts of experiment which might be deduced (were our instruments of calculation strong enough) from the fundamental six equations of dynamical equilibrium, are still among the insoluble problems which practice from time to time proposes to theory. Who for instance can determine the path of a particle of a disturbed fluid, except when the relative displacements of the particles are of the order of small quantities, and the differential equations become linear in consequence? And even then, how painfully do we mathematicians toil stumbling on, in the already trodden path of experimental research; witness for instance the mass of analysis devoted to the integration and interpretation of the well-known equation for disturbances in a solid medium which elucidate the phenomena of polarised light. The *cahiers* of Cauchy and Poisson, and the masterly papers of Prof. Stokes in the 'Cambridge Philosophical Magazine,' are all occupied with the solution of that one equation! Nor is the mathematical theory of geometrical optics an exception to the general rule; by means of much heavy and excessively ugly analysis we can calculate the magnifying powers, and measure to a tolerable degree of exactness the amount of spherical and chromatic aberration and of distortion and want of flatness in images produced by lenses, when the angle of aperture of the lens,

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its thickness, and the angle of the pencils of light are all small; and so obtain useful formulæ enough for the construction of telescopes, in which these conditions are generally fulfilled; but the case becomes very different when we attempt to apply the result of our investigations to the microscope, an instrument of perhaps as much importance as the telescope. A $\frac{1}{12}$-inch object-glass of Ross, or a $\frac{1}{16}$th of Powell and Lealand, or a $\frac{1}{25}$th of Smith and Beck, with their angular apertures of 170° and 130°, would be a sore puzzle for any mere mathematician to construct, if he were compelled to calculate by analysis only the curves of the lenses composing those several combinations; and in mathematical treatises on optics the very existence of the achromatic microscope is ignored or shuffled over, as if it were, as in very truth it is, a shame and a reproach to the science of symbols. Thus, even in Mr. Parkinson's improved edition of 'Griffin's Optics,' we are still presented with a figure of the compound microscope such as it was in the days of Culpepper and Boyle, when with its small angled chromatic objectives, and long clumsy body, it might have been justly defined, as it is in the work before us, as a telescope adapted for viewing near objects; and if we desire any further information on the subject, we are referred by Mr. Parkinson to Dr. Carpenter or Jabez Hogg. We would not however be understood as wishing to impute blame to Mr. Parkinson for this omission—the fact of the construction of the achromatic object-glass being beyond the range of analytical description, is sufficient apology for his apparent neglect. We think Mr. Parkinson's edition a great improvement on the old editions of 'Griffin's Optics'—the figures and illustrations are inserted in the text, and not in a single sheet at the end of the volume, so that we are not compelled to hunt amongst a maze of horrid spider's-web looking entanglements of lines and letters, for the particular one we require. Rhubarb and magnesia can by no artifice be converted into a pleasant summer beverage, nor can 'Griffin's Optics' be made relishing to the mental palate of the youthful inquirer after knowledge; however, all that can be done in that way has been done by Mr. Parkinson.

As 'Griffin's Optics' is one of the standard Cambridge text-books, and embodies perhaps more than any other, if we except 'Hymer's Astronomy,' a vast amount of those tedious theorems and interminably long formulæ which constitute what is known by the name of "cram" among University reading men, a rather detailed account of the plan of the book and of its contents may not be altogether without interest to our readers.

'Griffin's Optics' as improved by Mr. Parkinson is divided into eleven chapters of "bookwork," and ten chapters of problems. Of the "bookwork"—that is of the theorems and propositions in optical analysis which are required to be mastered by the mathematical candidate for "honours"—the first chapter is on "The reflection and refraction of light at plane and spherical surfaces, and the position of their geometrical foci," that is, of the points of convergence or divergence of indefinitely small angled pencils of light after direct reflection or refraction; where, by direct, we mean that the axis of the pencil is coincident with a normal to the surface. The second, on the "Illumination of surfaces;" and here we must render justice to the able manner in which Mr. Parkinson has treated of and explained this very interesting department of optical science, which was but very obscurely set forth in the older editions of 'Griffin's Optics.' The third is devoted to the aberration of small pencils, that is to say, to the small differences between the geometrical focus, or the point of alternate intersection of a ray proceeding to or from a given point, and directly incident on a reflecting or refracting surface, with the axis of the surface, and the point at which any exterior ray of a small conical pencil having the first ray for the axis of the cone, and for the vertex thereof the point of convergence or divergence of the first ray, meets the axis of the surface, which axis, or axis produced, is also the axis of the cone; and here begins some of that frightful cram which has rendered year after year 'Griffin's Optics' the despair of succeeding generations of freshmen: we select by way of example the following, from a number of similar formulæ which in the former editions the student was advised to commit to memory:—

$$\frac{\mu}{v^1} - \frac{1}{u} = \frac{\mu-1}{r} + \frac{1}{\mu^2}\left\{\frac{1}{r} - \frac{1}{u}\right\}^2\left\{\frac{1}{r} - \frac{\mu-1}{u}\right\}\frac{y^2}{2}$$

The whole of this chapter we should like to see omitted from Cambridge reading, but as the propositions established in it are required by the University examiners, Mr. Parkinson had no choice but to retain them.

Chapter iv. treats of the focal lines of small oblique pencils, and of caustics. The method of finding the position of the primary and secondary focal lines is very ingenious, and we have always considered this as the only neat and elegant bit of demonstration, half geometrical half analytical, to be found in the whole of optics. The caustics are well treated and explained by Mr. Parkinson; but as our readers do not perhaps all know what is meant by a "caustic," it may be as well to state that caustics are those bright lines of light produced by the intersection of rays reflected or refracted at curved surfaces: the curved lines of light that one sees sometimes on the surface of a cup of tea held between the eye and a candle, in particular positions with respect to the latter, are "caustics;" and numerous other instances will suggest themselves to the reader.

Chapter v., "On successive reflections and refractions at curved surfaces, and on the prism." Hitherto we have considered only the effects of reflection and refraction at a single surface, we now proceed to consider the effect of several such surfaces in combination on a pencil of light; a common magnifying glass is a simple example of two refracting surfaces in combination; and accordingly we are here introduced to the theory of the construction of lenses: as however the pencil of light is supposed to be always of small angular width, the formulæ obtained are hardly applicable to the object-glass of an achromatic microscope.

Chapter vi., "On refraction through media of varying density." The media previously contemplated were of uniform density, but on account of the varying density of the earth's atmosphere, and the peculiar kind of refraction of a star's image in consequence, it is of importance to calculate the effects of variation in the medium; and Mr. Parkinson has devoted accordingly a chapter to this question. We believe this chapter is quite an addition on his part, and that it did not exist in the older editions.

Chapter vii., "On the spherical aberration of lenses, or on the imperfection of images formed by a spherical lens," the imperfection being due to the fact of the pencil of rays having a sensible though small angle; here the formulæ become more and more complicated, and in the case of excentrical pencils, or pencils that do not pass through the centre of the lens, they are not even attempted to be worked out, but are copied as in all former editions, from 'Coddington's Optics,' which was we believe the basis of the present treatise by Messrs. Griffin and Parkinson. The whole of this chapter we should like to see omitted from the list of Cambridge "subjects." The object aimed at, the construction of a lens of small aberration, is better attained by the optician than by the mathematician; besides, the analysis is so frightfully heavy and bald, that as a praxis for the mathematical student, it would be utter waste of time to wade through it.

Chapter viii., "On images and caustics"—containing more unwieldy analysis, but some nice explanations as to the reason of distortion in images by Mr. Parkinson.

Chapter ix., "On the chromatic dispersion of light; or on the decomposition of white light into its elementary coloured rays. In the preceding eight chapters the light has been supposed to have been of one kind, but here we are introduced to the great fact of the division of white light into its coloured elementary rays by the prism, together with the theory of achromatic combination in lenses, and a lucid account of Fraunhofer's lines, or of the dark lines which divide the spectrum when carefully formed, and which were first observed by Fraunhofer.

Chapter x., "On vision and optical instruments." Most of these are fully described, but we think Mr. Parkinson might have done more than allude in a single sentence to the achromatic microscope, the greatest triumph that optical art has ever achieved.

Chapter xi. is devoted to the "Rainbow," and with this chapter the treatise on optics concludes; there are appended, however, eleven chapters of problems, by way of exercise for the student, and also, as we before hinted, as consolation and encouragement, to reward him for his labours already undergone, and to stimulate him to further effort, by proving that optical science is not all as barren of beauty as the "bookwork" of 'Griffin's Optics.'

Mr. Maxwell's tract is a reprint from his paper in the 'Quarterly Journal of Pure and Applied Mathematics', containing certain general theorems on the properties of optical instruments, which the author appears to have deduced and proved very ingeniously. We believe this little treatise of his to be a step in the right direction, that is to say, of mathematical investigation of general properties and principles, rather than of

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mathematical calculation of quantities, with regard to the images produced by microscopes and other optical instruments.

The most important of the nine propositions of Mr. Maxwell appears to us to be the last, in which he shows that it is impossible by means of any combination of reflections and refractions to produce a perfect image of an object at two different distances, unless the instrument be a telescope; but highly ingenious, and something indeed more than ingenious, broad and comprehensive as is the reasoning of Mr. Maxwell, we must, with all deference to the talented author, repeat our assertion that this tract of his is but a step in the right direction, and a great deal more is wanted in any investigation which is intended to be of practical utility to the optician. The optical theory of the telescope, including its eye-pieces, has been sufficiently explored; and the great desideratum now is an analytical discussion on the best form for the object-glass of the microscope; and hitherto, owing to the extreme crabbedness of the necessary analysis, no one we believe has been hardy enough to venture upon it. Besides, not merely would errors of spherical aberration and chromatism have to be dealt with, but also those arising from diffraction. The problem has indeed been solved practically, and to Mr. Joseph Jackson Lister and the late Mr. Andrew Ross are due the great merit of having patiently and by experiment elaborated the best curves, and the best distances between the doublets and triplets composing the object-glass: still, we should like to see their results confirmed by direct calculation. And surely no subject could be worthier the toil and meditation of our first-rate analysts, than this beautiful instrument, which has conferred, to say the least, as much benefit on science as the telescope itself. What wonders have not been revealed to us in natural history and physiology by the compound achromatic microscope! If the telescope guides us, so to speak, along the footsteps of God among the myriad worlds of the starry night, not less does the microscope reveal to us the delicate impress of His fingers in this our own earth. It is not too much to say that natural history as a science has only existed since the perfections of the achromatic microscope have classified its divisions, and based its whole superstructure on microscope anatomy. Until the unquestionably great difficulties of anything like a theoretical determination of the best curves for the lenses of an object-glass have been overcome, we shall feel that a great stigma attaches to mathematics, and every time we contemplate the perforated tissue of the siliceous shell of a keratoneis fasciculus with an objective by Powell, we feel inclined to distrust the vaunted power of our favourite science, and to think, foolish and momentary thought though it be, that engineers are not altogether to be blamed, when they make light of "your mere mathematicians!"

The Companion to the Almanack.—London: Knight and Co. 1860.

We recur, as we stated on a former occasion it was probable we should do, to this increasingly useful publication of Messrs. Knight. Continuing its comprehensive and valuable exposition of our architectural progress and of the passing events in relation thereto which have called for particular attention, it commences its *résumé* of such of the past year by some very pertinent remarks on the extensively debated subject of "the battle of the styles," as it is called; one which most if not all of our readers will be aware has embraced no inconsiderable portion of that period; taking to some extent the same view of the real points of the case as those to which we have ourselves given expression. It observes in reference to this matter, with we fear but too truthful a representation as regards the latter part of the observation, how "strange indeed to a looker on must the controversy have seemed —as proving, not merely how little the most prominent members of a great profession are agreed as to the first principles of the art they practice, but also how little they are accustomed to ascend to first principles at all." To whatever extent this may really be, however, let us hope for the future that it may have taught some at least that such are not without impunity to be wholly departed from, and that we may consequently find the time—which he admits will doubtless come—not quite so far distant as our essayist here imagines, "when," as he says, "the first question will be, not whether the style shall be Greek, Gothic, or Italian, but, How can we design an edifice that shall *perfectly* fulfil the object for which it is proposed to be built; and then, how, whilst preserving its perfect fitness, can we make it by suitable ornament proclaim its purpose distinctly, and adapt it best to the place it is to occupy? When design in architecture is looked at in any such way as this, the question of style will soon settle itself. As the Greek did not import bodily an Egyptian or Assryian type, but freely modified whatever he took so as to adapt it to his own requirements; and as the Gothic architect of the 12th, 13th, or any other century constructed, without regard to a foreign "style," his buildings so as to suit the needs of his employers: just so must we, if we would produce really true work, construct our buildings not by style and precedent, but strictly and solely with reference to our wants, and with all the advantages and innovations which enlarged experience, knowledge of materials, and the teaching of modern science will afford."

So much for the matter as regards its application to architects by profession: in reference to the opinions or judgment of amateurs, such may be fairly taken to be open to but secondary consideration. With questions of taste it is proverbial that there is no disputing, and beyond this, it has yet to be learned that the advocates of the latter description of either the one or the other of the opposing styles have really attempted to discuss or prove the merits of the issue joined between them. Lord John Manners has pronounced Mr. Scott's Gothic design "exquisite"; while Lord Palmerston has declared it to be "perfectly frightful"; and so, says our author, the subject "rests—or rather remains for it has caused such a disturbance in the architectural mind, that it is not likely to be permitted to rest for a long while yet to come." For ourselves, we are inclined to join in the continuing words of the work under notice, and to consider that it might be desirable that "its settlement should be deferred," if not "for another decade," at all events for the present. "Mr. Scott's design," as therein justly remarked, "has, as it could not fail to have, many picturesque and some excellent features; but is essentially ecclesiastical in character, and however well adapted it might have been for a foreign office in the mediæval times and circumstances, when clerics were the clerks and often the foreign ministers also, it is little less than monstrous to erect a foreign office in these days after the fashion of a monastery. Yet the 'Italian building,' which Lord Palmerston desiderates would probably be little more suitable, and little less costly—and again we say, with the recollection of recent great buildings before us, we would rather if possible wait a little longer before spending another half million or million, as the case may be, on what assuredly will be another magnificent mistake."

On the subject of the other national undertakings in hand or otherwise, it is remarked that—

"Of the progress of that other unlucky 'grand competition,' the Wellington Monument, we hear nothing. Probably it will again turn up along with the Foreign Office for settlement next session, and we shall again have members of the House of Commons revelling in artistic criticism, instead of discussing the dryer details of national finance, and vexatious Reform Bills. Of other national works there is nothing to record. The new Registry Office seeems forgotten. The lions are not yet placed on the Nelson Monument."

We might add to this that the New Record Office shows no vitality of movement towards completion. This is to be regretted, more perhaps on account of the state in which it tends to keep the noble erection of the Westminster Chapter-house, which now does duty in part for it, and the obstacles it places in the way of a fuller use of the valuable records there deposited, than from any desire which can possibly be created to see it perfected by the architectural pre-eminence or propriety of treatment of it as a professedly Gothic edifice.

Of the public distinguished from the national monuments of the past year, it is observed,—

"The pedestal of the Guards' Memorial, Waterloo-place, is completed, but it will probably be many months before the figures are in their places. The Westminster Memorial has made even less visible progress. But with both real progress has been made, though it is necessarily small, and necessarily unseen. Another of the Peel statues has been completed. It is of bronze, nine feet in height, stands in George-square, Glasgow, and is from the design of Mr. Mossman, of that city. The statue of the veteran reformer, Joseph Hume, by Mr. Calder Marshall, R.A., has been placed on its pedestal in the High-street, Montrose: it is nine feet high, of Portland stone, and is considered to be an excellent likeness. A statue of the celebrated Birmingham reformer, Thomas Attwood, was formally inaugurated at Birmingham on the anniversary of the Royal Assent to the Reform Act. A marble statue 9 feet high, by Mr. Woodington, of James Steel, editor and proprietor of the 'Carlisle Journal,' has been erected in the Market-place, Carlisle. A very fair but not first-rate seated marble statue, by Noble, of Isaac Barrow (chosen after some discussion as to who was Trinity's greatest man next Bacon and Newton),

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has been placed in the ante-chapel of Trinity College, Cambridge. Hugh Miller, the geologist of the old red sandstone, has been commemorated in his native town of Cromarty, by a colossal statue from the chisel of Mr. H. Ritchie. A statue of the gallant General Neill (by Noble) has been raised in Wellington-square, Ayr. The more ambitious monument by Lough, to be erected in Newcastle-on-Tyne, in honour of that true nature's nobleman, George Stephenson, is in progress—and may now unhappily be accompanied by one to his no less great son. In progress also are the Ellesmere and Anglesea Memorials, the Wedgewood Monument, and several others of general or local interest."

Of Metropolitan Churches, account commences with that of All Saints, Margaret-street, describing in detail its several features and enrichments, admitting at once its claims to be the richest of modern Pointed churches, praising where justly due, and at the same time remarking fairly upon the defects which it cannot be truly questioned but that it possesses, notwithstanding Mr. Street's unreserved eulogy of it. "Externally the building, though presenting some picturesque points," it is observed, is disappointing. "Only its south side is seen from the street, and that is inclosed within a narrow court-yard between two dingy, monastic-looking buildings,—a clergy-house and a school. The church itself, like these houses and the entrance gateway, is of dull red brick with bands of black brick." The clergy-house and the school here referred to are certainly far from the happiest exponents of the architect's capability. They are conventionalised to the extreme, and from a reference to and adaptation of not the very purest type. Of the interior our author says, "When the visitor enters the church, however, he will not wonder at the interest with which its progress has been watched by ecclesiologists, or the admiration they have lavished on it. Beyond question it is the most gorgeous church interior in the kingdom, and the one in which ecclesiological teaching has been most studiously followed; every part of it having been executed in accordance with mediæval precedent and symbolism." But it is added with undeniable truth as regards the stained glass of the south side and the west windows, by Gerente, of Paris, that "the forms are most resolutely mediæval in their ugliness," and "the colour is resolutely nineteenth century French in its absence of harmony." That of the clerestory windows of the chancel is also very questionable in its tone of colour, a sickly yellow predominating. The glass of the clerestory of the nave, on the contrary, by O'Connor, consisting of geometrical patterns and white grounds, has a fine effect. The pulpit and font are of coloured marbles, the former, "if not very handsome, is at least an elaborate and expensive one," it having cost nearly £400; while the proper effect of the latter may be said to be entirely negatived by the excess of its ornamentation. Its cover, overlaid with a profusion of brass-work, is of very ordinary form, and corresponds but faintly with the picturesque character and appearance of the rest of the bapistery features. The observations on this church are wound up with what must unhesitatingly be granted to contain, if not wholly, to a large extent, a true appreciation of the real facts of the case. "There can be no doubt," it is said in conclusion, "that the large expenditure incurred has been fairly returned in the splendour and, in its way, perfectness of the structure—and while we readily admit that the church is a very fine one," at the same time "we do not admit that it is the great work it is so loudly proclaimed to be. It is altogether wanting in that simplicity of constructive form which distinguishes the great works of every age and style, and which makes them, when divested of their decorations, retain their nobleness of character. All Saints' depends mainly, if not wholly, on its decorative features, but with its decorations it is a superb structure."

From other churches both in London and the provinces, of which a great number are remarked upon, and for which we must direct attention to the work itself, notice is extended more particularly, and in a more detailed form, to the one erected at Gerrard's Cross by Mr. Tite. On this it is observed as follows:—

"Turning to the provinces, we may commence our record of new churches with one that has obtained a somewhat unusual share of notice, from its being regarded in the light of a practical protest against the dominant Gothicism. Mr. W. Tite, M.P., from whose designs this church has been erected, we believe disclaims having had any such intention; but having distinguished himself in his place in the House of Commons, again as a witness before the Foreign Office Committee, and also at the head of the deputation of architects to Lord Palmerston, as the decided opponent of Gothic, it is not surprising that it should be considered that it was with some such purpose he designed the only church of any importance erected for a long time in which the Gothic element has been studiously excluded. Gerrard's Cross, where the church of St. James has been built, is a wide open common on the Oxford-road, between Uxbridge and Beaconsfield. The cost of the church (in all some £10,000) has been defrayed by the Misses Reid, who erected it as a memorial to their brother, Major-General Reid, late M.P. for Windsor. The particular style, it is said, was suggested by some association of the deceased general's early life. Be that as it may, we have standing on the midst of a wild common a somewhat ornate church, of which the type is that modification of the Byzantine which is seen in parts of Northern Italy. The plan is that of a Latin cross, from the intersection of the arms of which rises an octagonal cupola, whilst four square towers occupy the inner angles. At the north-western corner of the building is an Italian campanile. The windows are all narrow, round-arched, and raised higher than usual from the ground: at the eastern end, and in the transepts, three of them are grouped together. The roof is of comparatively low pitch. The nave is 100 feet long inside, the transepts about 60 feet, both nave and transepts being 21 ft. 6 in. wide, and 35 feet high. The dome is 67 feet high to the foot of the cross; the campanile is 13 feet higher. The materials are white brick in the plain surfaces, yellow brick in the recessed parts, the uniformity of surface being relieved by patterns of yellow and red bricks: stone is only employed where absolutely necessary."

With this general description of Mr. Tite's church we are however compelled from want of space to conclude our present notice: its fuller consideration will be entered into in our next, when we hope to continue our reference and extracts from the interesting book before us, and which we should hardly do justice to were we content to limit them to those we have now touched upon. Several other buildings and points in architectural interest are duly noted in it; and there are some observations in connection with a survey of our national collections of sculpture which are worthy of the fullest attention and publicity.

Rifled Ordnance. By LYNALL THOMAS, F.R.S.L.—London: Weale. [*Second notice.*]

ON THE NATURE OF THE ACTION OF FIRED GUNPOWDER.

This paper, which was by-the-by a paper read by the author before the Royal Society, is, we are sorry to say, a sad mistake. Mr. Thomas has shown so much talent, acumen, mathematical justness in conceiving physical ideas, and practical knowledge, throughout his treatise on rifled ordnance, that we are grieved to be at variance with him, as we must be on this—shall we call it his theory, or his crotchet?—as to the initial action of fired gunpowder. Let us first state what our own ideas on the subject are, and then we will endeavour to state the author's; in all fairness, be it observed, although not without a lurking hope that still we may have misunderstood, and so unconsciously have misrepresented him. We believe the motion of a bullet projected from a gun to be due solely to the pressure of the elastic gases set free by the powder; we believe also that the powder takes time to burn, and that it may or may not be all consumed before the ball has reached the end of the barrel. Mr. Thomas believes that there is something more than all this in the matter, and that the powder, independently of the pressure exerted by its freed gases (which pressure he admits to exist), exerts *instantaneously* a force of its own; in fact, to quote his own words, that "the initial action of the powder on the ball is impulsive."

To prove this point he employs a simple apparatus (we will suggest by-and-by a yet more simple one), consisting of a chamber hollowed out in gun metal, and provided with a touch-hole; upon this chamber he places a heavy ball, and in the chamber a small charge of powder, and he finds that when the powder is fired the ball is projected upwards with a small velocity. But to come to figures: with a charge of 1 dr. of powder and a ball of 4 lb. weight, the ball was thrown up to a height of 5 ft. 6 in. On this the author remarks, "If the only force in the previous experiment had been the pressure of the elastic fluid, the ball would simply have been raised a sufficient height to admit of the escape of the fluid, and would have dropped back to its place without rising to any great height." It is here that we are at issue with Mr. Thomas. We contend that a very great pressure was exerted on the ball, acting through perhaps a very short space; and that the velocity generated in the ball was due to that pressure and to nothing else. The truth is, to prove Mr. Thomas' proposition it would be necessary to show that the powder exerted no pressure at all on the ball through a finite space; but so far from that being the case, we will suggest to Mr. Thomas a series of experiments which shall prove directly the contrary. First, then, instead of using only 1 dr. of powder, let him take, say 2 ounces, inserted, not in a chamber of gun metal, but in one of much slighter materials, a piece of wooden tubing for instance, say 1½ inch in

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diameter and 2 inches deep, (or rather only deep enough to contain the powder), plugged securely at the bottom, and with a touch-hole for the insertion of a fuse; the thickness of the tubing not to be more than $\frac{1}{4}$th of an inch: if now he fires the powder with the ball weighing 4 lb. placed on the top of the tube, we undertake to say, he will have clear evidence of pressure in the condition of the tubing after the explosion. Again, let him repeat this experiment, only in lieu of placing the ball in *contact* with the powder (or rather with the tubing), let it be supported at a distance of about 1-10th of an inch from the end of the tubing, and the result, we venture to predict, will not be very different from what it was in the first case. If now the powder in the tube be fired *without the ball*, we think it probable that the tube may escape injury; but in the two first cases we should expect that it would be split into pieces. The fact is, the resistance opposed to the powder by the ball in contiguity to it, is sufficient to cause a great pressure, by retarding the escape of the elastic fluid. Mr. Thomas seems to think it absurd to suppose that in the same gun the same amount of powder should exert different pressures on the ball, according as the mass of the ball be small or great; but nothing is more easy to prove than this; for suppose A the area of a section of the gun, m the mass of the ball, Q the quantity of powder, t' the small time required to burn it all, and $\phi(t)$ some unknown function of t, the quantity at time t of elastic fluid at the pressure of the atmosphere given out by the gunpowder; then if π be the atmospheric pressure on the ball, x the distance from the bottom of the barrel of the ball at time t, the pressure on the ball will be $\left(\frac{\phi(t)}{A\dot{x}}\right)\pi$, and for the motion of the ball $m\frac{d^2x}{dt^2}=\left(\frac{\phi(t)}{A\dot{x}}\right)\pi$, which at once connects m the mass of the ball with $\frac{\phi(t)}{A\dot{x}}$.

Indeed, it is easy to see without the aid of mathematics that a heavy ball will retard the escape of the gases given off by the gunpowder more than a light ball would. We have in the above equation neglected the friction of the barrel, which would act as a retarding force, but the introduction of this force, whatever it may be, will not invalidate the truth of our statement that the pressure on the ball is a function of its mass.

There are some kinds of explosive compounds in which the combustion is so rapid, and the gases are set free so nearly instantaneously, that an enormous pressure is generated without the necessity of at all confining the explosion by means such as are resorted to in the case of gunpowder. A third of an ounce of fulminating mercury, *lying loose* on a deal plank of an inch thick, and accidentally exploded, at the laboratory of Hale College in the United States, made a clean hole in the plank: and some years ago a more fearful instance of the extraordinary pressure exerted by the explosion of fulminating mercury occurred at Apothecaries' Hall, when the late Mr. Herring lost his life; the powder in that instance was only confined in a thin glass bottle.

Again, remembering that the "work done" by a given force varies as the square of the velocity, let us examine more closely the numerical results of Mr. Thomas' experiments. With 2 dr. of powder, the iron ball weighing 4 lb. was projected 12 feet into the air, therefore the square of its velocity was $12 \times 2g = 768$, expressed in feet.

Now the velocity of a cannon ball is about 1200 feet a second at starting, and the square of this is 1,440,000, or something like 2000 times the square of the velocity of the iron ball; or the total force of the powder on the ball was infinitesimally small when compared to its effect on a bullet exposed to its full and sustained influence in a long tube. But we see that we have very much exceeded the limits we had proposed to ourselves at starting, so we must conclude, but not without heartily recommending to such of our readers as are interested in the "rifle" to procure Mr. Thomas' excellent work on the subject; and to Mr. Thomas himself, to abjure his heresy on the "Initial action of gunpowder," and in the future editions of 'Rifled Ordnance' to omit this most impotent conclusion of, with that single small exception, a most interesting, logical, and valuable book.

Examples of Modern Alphabets, Ornamental and Plain. Collected and engraved by F. Delamotte.—London: E. and F. N. Spon.

In our number for October 1858, we noticed a work entitled 'The Book of Ornamental Alphabets, Ancient and Modern, from the Ninth to the Nineteenth Century.' The one to which we now draw attention, by the same author, and bearing the title prefixed to this notice, may be taken as subsidiary to the former, the illustrations being confined to the several varieties of lettering exhibited in modern execution and design. The object sought is apparently, and with good reason, to render these familiar and of practical use, as the title-page expresses, to draughtsmen, decorative painters, engravers, and others whose avocations entail and of necessity call for a correct knowledge of the varied forms and artistic capabilities of the subject. For this purpose the work will be of considerable use, and the more so that it is produced at a price that will bring it within the reach of most who may desire and have occasion for its aid. There are forty-three different varieties of the alphabets now in ordinary use, as derived from the Hebrew, Greek, Roman, Saxon, Old English or Black Letter, German, and Italian, with a number of ornamented and differently treated versions of the same, some of which are very good, including English and German riband lettering, Perspective, Italian, Rustic, and Arabesque. The analytical principles of their construction, or guide to their proportionate formation, is also appended in several cases. A plate of Engrossing, and what is called Court-hand, is likewise added, as well as some examples of numerals. We doubt not but that the work will be largely consulted as a book of reference by the classes to whom it is more particularly addressed.

An Analysis of Ancient Domestic Architecture in Great Britain. By F. T. Dollman and J. R. Jobbins.—London: J. Masters.

We have frequently noticed with pleasure the labours of Mr. Dollman in the illustration of the Domestic phase of our ancient architecture: he is already known as the author of several works of great practical utility. The first two numbers of another book are now before us, produced by him in conjunction with Mr. J. R. Jobbins, entitled 'An Analysis of Ancient Domestic Architecture in Great Britain,' which is intended to be sufficiently comprehensive to give really an analysis of the subject. The work is to form two quarto volumes, containing 160 plates. Judging from the drawings we have had an opportunity of inspecting, there is no doubt that the authors will carry out their intentions satisfactorily, and produce a work that must prove a very valuable addition to what we already possess on the subject.

The plates in the portion before us are most carefully and forcibly executed, embracing subjects of archæological and architectural interest. Those devoted to the timbered house at Chiddingstone comprise a perspective view, accompanied by a geometric elevation and copious detail. These in the rendering are all that can be wished for, and though the subject is one of a late date, it is very suggestive in many points, and may be considered in the main to be exceedingly picturesque. The plate giving a plan with external and internal elevations of one of the windows of the hall of Oakham, in Rutlandshire, is a highly interesting example of a domestic window in stone of early date, transitional Norman,—one among many others which show clearly the distinction made between the domestic and the more strictly military portions of the castellated residence. In another plate we have in plan, elevation, and section, two good examples of fireplaces: one is apparently about the same age as the Oakham window, and exists in one of the upper rooms of the Earl of Westmoreland's seat, Apethorpe-house, Northamptonshire. The other is of later date, and is from what was formerly the withdrawing room, according to Leland, of the ancient manor-house of the Bishops of Lincoln, afterwards (in the year 1602) converted into an hospital by Thomas Earl of Exeter, and now known as the Almshouses of Lyddington, in Rutlandshire. One of hooded form is similar in design to most of the earlier and immediately subsequent examples, of which there are anterior and coeval evidences yet extant at Coningsborough and Aydon, and later at Netley Abbey. Another example is of a flat arched and recessed fireplace of the Perpendicular period, its mantle portion enriched with panels filled with tracery.

The four remaining plates in these two numbers of the work illustrate the ancient Hospital of St. John, Northampton, the exterior of which has some peculiarities worthy of observation.

A concise descriptive account accompanies each subject, and at the same time incidentally refers to such other features of interest as may also exist in the buildings. This part of the book has been prepared with the care usually evinced by Mr. Dollman, and otherwise the work promises to well sustain the reputation for accuracy of representation and artistic power of execution already respectively earned by the producers.

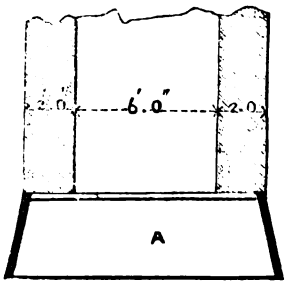
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INDIAN WELL-SINKING FOR FOUNDATIONS.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

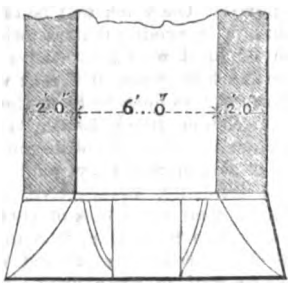
SIR,—Alluding to an article which appeared in last month's *Civil Engineer and Architect's Journal*, I would suggest a cradle, of the kind shown in Fig. 1, of cast-iron instead of timber, as

FIG. 1.



Section showing concrete when built up.
A. Concrete.

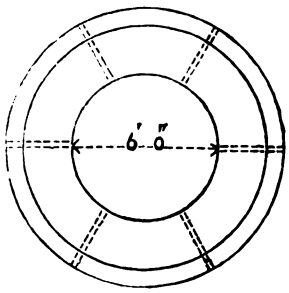
FIG. 2.



Section showing curb.

being better adapted to sink and cut through sand and clay to a convenient depth for the settling of the shaft. When sunk to a

FIG. 3.



Plan of curb.

sufficient depth, to be filled up with concrete, as shown in Fig. 2, thereby preventing filling up with sand and water, which would draw upon the other shafts in the immediate neighbourhood.

Liverpool, 21st Dec. 1859. R.

NOTES OF THE MONTH.

The Metropolitan Railway.—The works of this railway are to be forthwith vigorously proceeded with. The western portion, from Paddington to Euston-square, are contracted for by Messrs. Smith and Knight; and the eastern portion, from Euston-square to Victoria-street, City, by Mr. John Jay. The route will be from the Great Western Railway station at Paddington along South-wharf-road, Praed-street, Marylebone-road, Euston-road, Bagnigge-wells-road, to Victoria-street, near the foot of Holborn-hill. There will be a branch in connection with the Great Northern Railway at King's-cross. The railway, nearly throughout, will be in a tunnel, the crown of which will be just under the surface of the present roads. Besides terminus stations at Praed-street and Victoria-street, there will be numerous intermediate stations along the route for the accommodation of passengers. The first essential work to be done of course is to provide for the necessary drainage of the railway and of the sewers intersected by it. For this purpose Messrs. Smith and Knight, the contractors before mentioned, have begun a new main sewer in Conduit-street, Paddington, which will be continued across Westbourne-terrace, and along Praed-street and South-wharf-road, to the Edgeware-road, at a depth of 30 feet below the surface. The workmen in Conduit-street have already laid bare an interesting relic of the past,—no less than the foundation of the famous old conduit that formerly supplied a portion of the City with the sparkling spring-water which abounded in the extensive bed of gravel and sand about Paddington.

The Brunel Memorial—Upwards of £1600 have been subscribed towards the proposed memorial to the late Mr. Brunel; but as this is not sufficient to accomplish the design of the promoters, the subscription lists will remain open till the committee shall determine as to the specific appropriation of the fund.

The Collections of the British Museum.—The trustees of the British Museum have just decided upon the separation of the natural history collections from the books and fine arts collections. Thanks to this decision, we may at last hope to see both the natural history specimens and the fine art treasures of the Museum properly located. At this moment each of these collections incommodes and crowds on the other. There is nearly as much in the way of zoology and sculpture hidden away in dark and inaccessible vaults and corners, as there is visible to the public, or rather to the students, for theirs is the interest to be mainly considered.

The President of the Royal Institute of British Architects.—A very numerous and influential meeting of the Institute was held on the 15th ult. to elect a President in the place of the late Right Hon. Earl de Grey; Mr. George Godwin, V.P., in the chair. Mr. Tite, M.P., moved a resolution affirming that on the present occasion the president should be elected from amongst the Fellows of the Institute. Prof. Donaldson moved an amendment to the effect that the Council should invite some distinguished nobleman to accept the office. Mr. Scott, A.R.A., Mr. Smirke, R.A., Mr. Pennethorne, Mr. Barry, Mr. Wyatt, and others spoke on the subject, and ultimately the motion and amendment were withdrawn, and Mr. Cockerell, R.A., was elected President.

Public Works at the Cape.—A line of rail is to be formed from Cape Town to the suburban districts of Mowbray, Claremont, and Wynberg, and the construction of a line from Port Elizabeth to Graham's Town, is in contemplation. A new patent slip and pier are being constructed at Simon's Bay: the cost will be £16,000.

Exhibition of the Works of Living Artists.—A general exhibition with this object will open at Brussels on the 1st of August next, and close on the 30th of September.

Propulsion of Cars on City Railroads.—At a recent meeting of the Franklin Institution, in reply to a question by a member, "if any plan to propel the cars on city passenger railroads had been proposed in lieu of horses," it was stated that the caloric or hot air engine was about to be applied to that purpose in New York, the first machine being nearly ready for trial. Another means of propulsion seems to have been hit upon by several persons, as soon as the necessity for some cheaper motor than horse-flesh became apparent. The directors of two or three roads, on application, were advised to use compressed air, operating engines of small cylinder capacity, running quickly, and supplied with air of a high density; the motion being transmitted through geared wheels to the driving axles. With either of the plans no change would be required in the existing cars, as the engines could be suspended beneath the floors, or on one of the platforms, whilst the air reservoirs could be placed on either side of the car, and form the seats. If reservoirs of a capacity sufficient to maintain a working pressure during the entire run could not be had, they might be refilled at some intermediate point, say at the intersection of a cross road, where the compressing engines and supply reservoirs might be stationed, thus serving two roads: the time occupied in filling the reservoir being merely that consumed in making the attachment, say one minute. The heavy grades on some of the roads can be overcome by a change of gear wheels operated by the engine man; the engines running at usual speed, whilst that of the car is reduced one-half or one-third. The objections urged against the use of steam, as, danger of explosion, heat and smoke, are nearly removed, whilst the exhaust motor being invisible would give no fright to horses. Vehicles could be warned off the track by an air-whistle, and the approach to a crossing or a connecting road made known. It is said that an air engine is being built for a Philadelphia road by an engineer who has just completed a successful locomotive engine driven by compressed air, for a road in the mining region. It has two cylinders of moderate capacity supplied with air of 200 lbs. initial pressure, contained in a reservoir of about 75 cubic feet. With the above pressure it ran about 2000 feet, pushing six loaded drift-cars upon which were clustered over 50 men. No novelty is claimed in the use of compressed air as a motor, numerous experiments and successful workings being recorded in books; but it seems to be specially adapted to this purpose, and will, no doubt, much reduce the running expenses of cars, each of which requires six horses per day to make its usual trips.

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ST. MATTHEW'S CHURCH, COBO, GUERNSEY.

(With Engravings.)

A picturesque little church has lately been erected in the parish of St. Mary de Castro, in the island of Guernsey, a small hamlet within a quarter of a mile of the sea-shore. We are pleased in being able to give an illustration of this church, with some of its details, since it not only possesses more than ordinary merit, but is a good proof of the adaptability of the Norman style to such positions as that it occupies. It was erected for the use of the fishermen of the locality.

The exterior is built of granite in random-courses, the quoins and arris-work of dressed granite. The plan is simple in form, having a nave and chancel of most excellent proportions, the latter being equal to one-half of the nave. On entering the porch, which is on the south side, is seen the Caen stone font, consisting of a large circular bowl supported on a square base, on each face of which is carved a sign of one of the Evangelists, the bowl externally being diapered. The roof is open framed, stained and varnished. The chancel is paved with Minton's ornamental encaustic tiles, and the chancel windows are filled with stained glass, of designs of the period.

We call particular attention to the external portion of the chancel at the apex of the cone. In consequence of the extreme curvature of this portion, it was found to be necessary to cover it with lead instead of slate: the ridge and portion of the roof is projected further than usual so as to form a hood, thus securing an efficient protection from the weather, and at the same time an effective feature, one, we think, worthy of imitation. The west end has an arcaded triplet.

To the north is placed the parsonage, of Early Pointed character, built of the same material, granite. A lich-gate marks the entrance from the roadway: it stands midway between the church and parsonage, uniting pictorially, as seen on the west side, the two buildings, the whole forming a very pleasing and effective group.

The church has accommodation for 260 adults, and 36 children. The length of nave is 59 feet; width of ditto 27 feet; length of chancel 26 ft. 9 in.; width of ditto 16 feet; height from floor to ridge 41 feet. The cost of the church was £2100. The greater portion of the expense has been defrayed by the family of the late General Carey, by whom it has been endowed.

The contractor, Mr. D. de Putron, of St. Peter's Port, has executed the works to the entire satisfaction of the architect, Mr. John Johnson, of John-street, Adelphi, London.

ON THE TREATMENT OF SUBSERVIENT FEATURES AND ACCESSORIES EXHIBITED IN SOME LATELY ERECTED BUILDINGS.

Mr. Editor,—Our architectural progress, æsthetical as well as mechanical or constructive, is a subject in which the generality, if not all, of your readers will, I imagine, take interest, those of the profession doubly so; and the right-thinking among the latter will, I feel sure, consider no excuse or apology necessary for a few critical observations, even though they do not altogether convey the note of praise to their ears as respects the works of which they themselves are the producers, provided the contrary, as will sometimes happen, may be justly due. A man's best friend, it is generally admitted, is he who is not blind to, and reminds him, as necessity may arise, of his faults; and the same observation may be considered to equally apply to the case of his artistic mistakes. The aphorism that we live to learn is, among all but the determinedly obstinate and prejudiced, unhesitatingly acknowledged; and there are few of the properly constituted in the world of art who will imagine that they might not have done better, or having committed offences occasionally against good taste and propriety, will be unwilling that such should be remarked upon, to their avoidance for the future, and consequential benefit directly to themselves, and indirectly to others. At all events, this should be the temper in which just criticism in matters of art and taste should be received, and however far the latter, according to the old proverb, is not to be disputed with, yet there are general laws and principles in relation thereto which all will readily concede should not be violently or grossly offended against or infringed upon. In hardly any other art than architecture are such departures from the received canons more offensive. It has been rightly observed that "a thing of beauty is a joy for ever." The reverse, materially petrified, or in other words fixed in stone, is a lasting injury and cause of regret, proportioned only to the durability of the material in which it may be executed; to secure themselves from the perpetration of which very few who practise and feel correctly towards art would hesitate to be subjected to some amount of a cauterising process, provided such were fairly called for. These observations however, Mr. Editor, are simply preparatory to those which it is my purpose particularly to address to you, and are merely intended to show the actuating animus, or feeling, with which as occasion may require such of the latter as take a deprecatory tone are made. Having premised thus much therefore, I will proceed to the main subject of my present communication.

Within the last few years, as most are aware, a remarkable impetus has been given to architecture, and an amount of consideration and patronage bestowed upon it far exceeding any that has for long preceded. Ecclesiological and architectural societies, established all over the kingdom, have advocated the claims and fostered in every way the consideration and development of the true principles and correct phases of architectural art. The results have been a widely improved state of knowledge amongst its professors, and an extended appreciation of architectural correctness and propriety amongst its patrons and the educated public generally. The productions of twenty, or even ten years ago, would now be rejected almost universally; while the better tutored eye and more improved observation of the present day refuses to extend its approbation except to that which satisfies more nearly and clearly the established requirements of good taste, fitness to purpose, and expression. From many late erections this fact would seem to be insufficiently admitted by their producers, and, whether the consequence of inattention to it, or the result of a want of an architectural creative power equal to the wants of the time, he does good service who endeavours to awaken the erring on the former ground, or gives helping hand to the deficiencies of the latter. It may be, perhaps, that occasionally, or in the present case, the old fable of the Lion and the Mouse may be shadowed forth, particularly as far as the insignificance of the latter, or the agent, is concerned in such attempt; yet the lordly lion is represented as having confessed his obligation to the mouse; and I am inclined to think that the moral or inference here conveyed would be by no means limited in its application.

In the direction and purport of these remarks I have been led by an observation of one or two buildings lately erected, which, without being such as may be considered pretentious, have sufficient of the attempt at the *modus propriarum*, if not *elegantiarum*, to place them without the pale of the ordinary kind, in which correct treatment and effect would be of less consequence,—if under any circumstances at least such insufficiency or want may be properly allowed. In the first of the cases to which I shall allude this is the more to be regretted, because the architect has on more than one occasion shown a capability, and has established a reputation, which would naturally lead to the expectation that all points of his design would have the requisite amount of his consideration. It is possible in the present instance, it may be objected, that he has had (what architects however generally experience) the difficulty of limited funds to contend with; but this does not necessarily entail the absence of a proper agreement of one portion with another in the same design; or the introduction of that which is in itself ugly, or constitutes a departure from the most convenient disposition of parts or accessories necessary to the completeness or practical utility of the building. Objects which are objectionable on these grounds are seldom as a general rule less costly than their opposite; while it is on the proper and relative treatment of subservient details, quite as much as on fitting expression and proper arrangement of the main points or portions, that a satisfactory result either artistically or otherwise is to be attained.

Adjoining the Roman Catholic church of St. Mary, at Bayswater, is a building lately erected as a presbytery or clergy-house. It comprises a basement story, containing the kitchen and offices of the establishment; a ground story, consisting of a common room and refectory, with corridor, and a large turret staircase from the street entrance to the same, continued for access to each story above. The first and second floors are appropriated as dormitories and private rooms for the residents; and the upper story, formed in the roof, is the library. The building is con-

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structed of stock brick, with bands of Kentish rag-stone at the line of the several floors, &c., and freestone is employed to the principal windows, and as copings, and for cornices, &c. The style is an adaptation of the early French Gothic, and is, notwithstanding a few anomalies, and the want of consideration of minor points, to which I shall now allude, on the whole effective and successful.

To commence with the basement. Here, while all the upper and principal windows have stone jambs and heads, straight arches of brick, the weakest of all forms of arch, are introduced, to the loss of even the appearance, independently of the actual strength desirable on this situation; and to the exclusion of that relative correspondence which should more or less exist in parts brought into view at the same time in the same façade. The like want of harmony—indeed to a greater extent, for, the basement windows have stone springing-pieces, while here there is a total absence of the superior material—is also apparent in the small windows which light the staircase at the angle. These are treated as the commonest description of perforation in a wall. They have the ordinary straight-gauged arch in the head, with brick reveal, and are altogether of the simplest house-building type. At the street level is a good plain doorway of entrance, and above it a square-headed stone niche, of correct detail, for a statue. The raking gable formed by the projection of the plane in which the door is placed beyond the cant of the staircase turret, is covered with a stone coping, which there is no good reason should not appear as a series of tablings, according to the preferable mode of construction anciently adopted, since it is really coped with several pieces of stone, and under the flush-jointed process employed gives less idea of safety from, as well as actually affords less protection against, the admission of moisture, than the older method. This is perhaps more of a practical than an æsthetical question, but as considerations of the latter kind are naturally and largely involved in the consistent and effective application, viewed in the former light, of the component parts of any architectural feature, such are points to be attended to, and which cannot be wholly separated from or taken to be independent the one of the other.

On the principal floor, or *rez de chaussée* of the French houses, is as before observed the common room, overlooking the street, and the refectory, forming the north side of an interior court. This latter room is a very effective apartment, and strictly monastic in its appearance. There is some good modern stained glass in geometric patterns in the windows, and a well designed chimney. It has at the lower end a lectorium or reading-pulpit, after the old fashion. The floor is paved with tile in patterns; and the view of the room altogether, with the corridor through which you approach it, transports the visitor at once in imagination to the similar apartment in the foreign monasteries of the mediæval age. It is to be wished encomium of a like kind were deserved in the case of the common room. This has been but cavalierly treated internally, and externally the windows show a character which, if not wholly out of keeping with the rest, are anything but such as the architect who admitted them could with very little trouble have supplanted, with more appropriate effect and better proportion. They are in fact such windows as are frequently found in early French churches, but seldom, as far as my observation has extended, in the more strictly domestic portions of an ecclesiastical building. They are formed each of two round-headed lights, with a semicircle above, under one superior arch. The section of the mullion and jambs is a plain splay; and they are filled with quarry glazing, with plain iron stanchions and cross or saddle bars. And this brings me to the next point in the treatment of the subservient features of this building: the windows just described have the quarry glazing of mediæval times, in all the other windows—those of the refectory with its corridor, and the circular lights of the turret excepted—the square wooden sash glazing of modern times, and of small size, is introduced. This is bad enough when the excuse is offerable for it—and which, by-the-by, might be readily rendered unnecessary—that the sliding sash best keeps out the weather. Here however the latter is not used; the aperture being filled with a fixed sash, the lower quarter or fourth part of which opens as a casement.

In an elevation or design characteristically French, surely it would have been more consistent to have referred to and adopted the old casement system of that country, of which there are so many examples yet preserved, and of which the architect of the building under review has himself given interesting illustrations in his work on the Ancient Domestic Architecture of France, or why should that which has neither beauty or superior usefulness to recommend it supersede that which would more fittingly carry out the expression sought to be given. As respects the particular point in debate, the present day affords facilities for the introduction of glass in a manner very different to that which could be indulged in formerly. The material is cheapened very greatly, and by many arrangements we might avoid with a little thought the error of glazing a building, Mediæval or otherwise in its tone and profession, with window fittings in the mode of a date which has nothing in common with the other features of a period intended to be represented; besides returning to a treatment and arrangements which the restrictions offered by the material employed, or other necessity, no longer calls for.

There are, in addition to those which I have above adverted to, two other points in connection with this building which I cannot refrain from remarking also upon; but these, Mr. Editor, having trespassed already so much on your space, I will defer to a future opportunity, when I hope to interest your attention, and that of your readers of the architectural profession especially, so far as to follow me in the few further observations I shall have to make on the same subject, to which I alluded in the first part of my present communication.—I am, &c.

CENSOR.

IRON AQUEDUCT BRIDGE, WASHINGTON, U.S.

AMONG the public works now in course of completion at Washington, one of the most remarkable though least known, is the Washington Aqueduct Bridge over Rock Creek, at the western end of Pennsylvania-avenue, now nearly completed from the designs and under the direction of Capt. Meigs. This bridge is a cast-iron arch of twenty feet rise and two hundred feet clear span between the abutments. The arch consists of two ribs, each of which is composed of seventeen cast-iron pipes of forty-eight inches internal diameter, and twelve feet three inches in length. They have flanged ends pierced with holes for screw bolts, by which the pipes are firmly connected together. After being cast, they were placed in a lathe, and the ends and flanges were accurately turned or faced off. They are put together in the form of a circular arc, the faced ends abutting against each other, and forty screw bolts firmly secure each joint. Such is the accuracy obtained by the present use of machinery in engineering, that these joints are water-tight under the aqueduct pressure of 120 feet head, by mere application of the dressed surfaces of cast-iron, no packing or cement being used in the joints.

Upon these two arched ribs, which are firmly connected with each other by cast-iron tubular cross braces, and heavy wrought-iron diagonal ties, is erected a framework of heavy rolled iron H beams, from the works of the Phœnix Iron Company, of Philadelphia, supporting two continuous horizontal iron girders, of two hundred and four feet six inches in length. Upon these girders rest cross-beams of timber, supporting the roadway of the bridge, which embraces two city railroad and carriage tracks and two paths for foot passengers. The cornice of the bridge is decorated with modillions of cast-iron, and a light wrought-iron railing surmounts the whole. The abutments, founded upon solid rock, are built in the most substantial and durable manner, of a fine grey sandstone, obtained in large blocks from the government quarries at Seneca, upon the Chesapeake and Ohio Canal, twenty-four miles from the city of Washington. The strength of this stone is seventeen thousand pounds per square inch.

This bridge is remarkable for the double duty which the arch performs. While it supports a roadway, forming a beautiful and much needed communication by which the traffic between the cities of Washington and Georgetown is carried over, the water of the Washington aqueduct is conveyed into the city of Washington through the pipes of which the arch is composed. To guard against all danger of freezing, the pipes are lined with staves and resinous pine timber, three inches in thickness, leaving a clear water-way in each rib of three and a half feet in diameter. The flanges and bolts by which the pipes are connected at the joints are covered with decorative mouldings, encircled with foliage in cast-iron. The arch ribs spring from ornamental bases, which distribute the pressure over huge blocks of granite set in the skew back of the abutments. The intersections of the beams in the frame work of the spandrils are covered with ornamental bosses, also of cast iron. The whole is a model of lightness and

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elegance, being two hundred feet in clear span and forty-five feet in height from the water to the top of the parapet.

The abutments contain vaults, in which are the connecting pipes and stop-cocks for regulating the flow and discharge of water, and in the western abutments on the Georgetown side one of the vaults serves as an engine-room, and contains a water pressure engine—the first, it is believed, erected in the States. This engine, drawing its supply from the cast-iron street mains of the Washington aqueduct, pumps ten thousand gallons water per hour into a reservoir on the heights of Georgetown, a mile distant, and two hundred and four feet above the machine. This reservoir supplies that portion of Georgetown which is above the level of the great store and distributing reservoirs of the Washington aqueduct. The engine and pumps were built by H. B. Worthington, of New York.

The Washington aqueduct has other works not less remarkable than this one; among them the great granite arch by which the masonry aqueduct, nine feet in diameter, crosses the Cabin John Creek, at a height of one hundred and one feet above the bed of the stream. This arch is built of hewn granite, is twenty feet wide, fifty-seven feet three inches rise, and two hundred and twenty feet in clear span.

ST. JOHN THE BAPTIST'S CHURCH, COVENTRY.

This church was re-opened on the 26th ult.; it having been closed for several months for partial repairs and restoration. The works are still to be carried on, and it is hoped till all be satisfactorily completed, but what has been hitherto accomplished was rendered absolutely necessary owing to its frightful state of decay, and the danger which the fabric everywhere threatened. The substantial portion as yet unaccomplished is the renovation of the chancel, while, to render the whole perfect, the open parapets generally and other portions of the ornamental stonework, with the whole of the internal fittings, must be entirely new. The building is in many respects a curious one; its plan is cruciform, with transepts extending only to the wall line of the aisles of the nave and chancel, thus presenting a continuous line of surface on the north and south sides, broken only by small buttresses. The tower, simple and comparatively plain, rises from the intersection; it is of two stages, each face being pierced by two small two-light windows, and divided by slender buttresses, which are repeated at the angles. The parapet of this tower is singular, on account of the castellated idea which it suggests, each of its four corners being corbelled out from below the cornice so as to terminate in a circular form, embattled like the rest of the parapet, as is not unfrequent in Scotch domestic work. At the north-east angle is a circular staircase, which exhibits this outline from the base, and finishes at the top higher than the general level of the rest. Among the singularities of this building is the fact that scarcely any two walls are parallel, and the irregularity caused by this want of squareness is very perceptible as the eye ranges from roof to roof internally. Another peculiarity is the shortness of its nave when compared with the chancel, &c., and the great loftiness throughout (the ridges being all kept level), though this is less noticeable now from the outside owing to the ground having been raised several feet; indeed the level of the floor within is at present far above the original line. The works are being carried on under the superintendence of Mr. G. G. Scott, and the contractors are Messrs. Thompson and Ruddle, of Peterborough.

CARVING BY MACHINERY.

None who have a love for the fine arts can fail to acknowledge the exquisite design and delicacy of manipulation so remarkably displayed in the works of such consummate artists as Grinling Gibbons, Jean Goujon, Donatelli, Lorenzo Ghiberti, Peter Vischer, Mesonnier and others, who filled the churches and mansions of England, France, Italy, and Germany with endless examples of their matchless skill. On the other hand we cannot but admit and deplore the humiliating fact that within the past century we have achieved nothing remarkably great either in our ecclesiastical or secular edifices, or in which superior skill has been displayed in cutting from the solid: many works in the old cathedrals, and those of Gibbons in their particular class, as in the choir of St. Paul's cathedral, and the triumphs of his genius at Chatsworth and Petworth, still remaining unequalled and alone.

Let us however hope in reference to carved works that we are on the eve of a revival, and hail with pleasure any step in the right direction to improve an art which has so many claims on our esteem. It is apparent that one of the greatest obstacles in the way of improvement in carvings is the excessive cost, necessitated heretofore in requiring the artist to rough-hew his work, by which much of his valuable time was wasted in removing extraneous material only, which might have been accomplished by an ordinary artizan.

We have with considerable pleasure visited the establishment of Messrs. Cox and Son, Belvedere-road, Lambeth, who have accomplished by their admirable machinery this great service to the art, and who by its aid produce highly artistic works in wood, metal, alabaster, stone and metal, for ecclesiastical and secular purposes. When we speak of Messrs. Cox and Son's "machines" we do so far want of a better epithet to apply to them, for strictly speaking they are not machines, but tools worked by steam, the powers of which have been enormously augmented by velocity of motion; and which at the same time are under the perfect guidance and control of the workman who makes use of them. The invention is founded upon Jordan's patent, and in its application to carving on wood consists of a rectangular shaped table, over which is a framework, on which what are termed the cutters and "guide" are fixed vertically, these revolving with such rapidity that 7000 revolutions are effected per minute. These work within a groove, the guide being in the centre of the frame, having the pattern piece to be carved immediately underneath it, traversing it in all directions, and whilst doing so the cutters are entirely under its control, and drill away the extraneous wood down to the required line with the greatest precision. Several panels or other examples can thus be worked at the same time, one cutter being employed upon each piece of carving.

These machines are not intended to supersede hand-labour, but to accomplish that process of the art of carving which will save the time of the more accomplished artist, and in reference to wood is equivalent to what was effected by Chantrey, the sculptor, in the pointing machine, as applied to marble and stone. Carved works will thus be produced at a considerably reduced cost, and yet of a superior description, artists being employed to follow the work of the machines, in order to give it those delicate touches of manipulation without which carvings are valueless.

Some of our most eminent architects and builders are beginning to appreciate the facilities and cheapness of production offered by these machines; and assuredly large contractors for ecclesiastical and other works where carvings in wood, marble, alabaster, and stone are introduced, would do well to avail themselves of the advantages offered by the patentees. One kind occurs to us of external decoration amongst many to which the machinery is admirably adapted, we mean gable barge-boards, which when executed in oak give such a characteristic feature to villas of the domestic Gothic class.

Amongst the more prominent works at the establishment we noticed some handsomely carved screens, an oak pulpit and reading-desk with fittings, executed for the chapel of the Middlesex Industrial Schools at Feltham, recently erected from the designs of Messrs. Banks and Barry; a richly decorated pulpit with tracery panels, inserted in which are symbolic representations of the Evangelists, surrounded by mouldings of boldly carved foliage. This fine pulpit rests upon elaborately carved pillars, and is intended for the church of St. Mary, Plymton; designed by Mr. R. Elliott, architect, Plymouth. An altar table for Sydenham Church, from a design by Mr. G. Nash, attracted our attention as very bold and original in its treatment; also an elaborately finished front for a gallery, and an organ case, from the designs of Mr. Alfred Smith, architect, Adelphi, intended for a church at Sydney, Australia.

Among some specimens splendidly designed for domestic purposes, as fittings and furniture for mansions, are a massive oak chimney-piece of excellent design and execution, 10 feet in height, superbly embellished in figures, shields and foliage; and a pair of large folding-doors, elaborately decorated with architraves and jambs complete. These doors are constructed for Lady Esmonde, and will be fixed in her mansion, Johnstown Castle, Wexford. Lady Esmonde, who is a great patron and lover of art, has recently designed the fittings for one end of a drawing-room. This work, which is entirely composed of wainscot, consists of deep narrow recesses on each side, having canopied heads with crockets and

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finials, the whole being surmounted by an embattled cornice, highly enriched. These recesses or niches are filled with statues cut from the solid in oak.

At their show-rooms, Southampton-street, Strand, Messrs. Cox and Son exhibit several excellent specimens of their carvings in Caen stone and wood, consisting principally of ecclesiastical and other furniture. We wish them every success in these well-directed efforts towards cheapening carved works of a very superior character.

EXHIBITION OF THE SOCIETY OF FEMALE ARTISTS.

It may be presumed, from the fact of this exhibition having removed this year from its humbler quarters in the Haymarket to the recognised pictorial region of Pall-mall, it being now located in the Galleries of the New Society of Painters in Water-Colours, that is now gaining, as it should do, a permanent footing. This is but the fourth year of its existence, and the show on the walls is both abundant and on the whole very satisfactory. It is to be expected that our sister artists should in some degree differ from those of the other sex in the selection of their subjects, and in the style of treating them, so that this in itself is a sufficient warrant for their encouragement in their own peculiar channel, while it must also be acknowledged that in other branches they are not unfrequently worthy coadjutors.

The names of several female artists have long been associated with flower painting of the most exquisite kind, and several good specimens are to be seen in the present collection; they likewise excel, as may naturally be supposed, in subjects involving delicacy of touch and careful finish. Some of the copies from the "old masters," which are so liberally interspersed with original productions, may be quoted in illustration of this, though it may be questioned how far it is advisable to perpetuate this system of admitting copies by wholesale into an exhibition which has, or at least ought to have, all the elements of stamina for its independent existence. A glance at the catalogue will show the extent to which this has been sanctioned: to enumerate but a portion of the names, we find Murillo, Correggio, Francia, Guido, Claude, Gainsborough, Reynolds, Turner, &c., all more or less worthily represented, few of them being improved by the diminished scale on which they are reproduced.

Of subjects which come more especially within our province in connection with this journal, we must allude first to some excellent architectural delineations, such as those by Miss Rayner, who has long devoted her talents to works of this class. Of the five pictures contributed by this lady each has its individual merit, but the first, (90) "Market-place, Wells," is perhaps the least satisfactory, the whole evidencing want of "keeping," as well as a carelessness in the distant details which is unusual. "Broad Street, Bristol" (95), is a picture of high merit; and the two views of Canterbury Cathedral are exceedingly good, but familiar to those who possess Britton's illustrations of that fabric. Early in the catalogue we meet with "Venice, after Prout" (20), by Miss Hasker, which we note as a free-hand copy of a bold master. (47) "Interior of the Hall of Beaulieu Abbey," by Lady Edward Thynne, is very cleverly shown, both pictorially and architecturally; as is also a "Tomb in the north aisle of Westminster Abbey," by Miss C. Babb (73). In both these due regard has been paid to the minutiæ of the effect of mouldings as well as masses. "Pluckardine Abbey" (82), by Lady Belcher, is boldly handled, and still more so is (169), "Kidwelly Castle," by the same artist: it is a truly charming picture. A large oil painting of the "Ruins of Karnac," by Mrs. R. Blaine (55), will attract attention for its peculiar colours and solemn grandeur of scene, as also another eastern study (68) which is also hers. Mrs. Dale's three contributions (84, 194, 299) are among the best of their class, the first in particular, representing a half-timbered cottage, is especially well rendered. Among the cleverest architectural delineations we must mention (87) "Tewkesbury," by Mrs. Wilkes, a picturesque and truthful view. In (118) Mrs. Worsley has well expressed the forms of Gothic vaulting, the view being taken in the church of St. Pierre, Caen; and three nicely touched-in sketches in brown ink (292) of Italian scenes must not be overlooked. A large view of an "Old Street in Canterbury" (140), by Miss Grant, is too ambitious, and not well made out; this picture may be well contrasted with a neighbouring one (157), in which Miss J. G. Jones has accurately portrayed the well known "Watergate Street, Chester." (170) "Organ Gallery at the Church of St. Maclon, Rouen," by Mrs. Worsley, is a good sketch, but rather too hard in its colouring; a defect which is still more perceptible in (203 and 310), two interior views of St. Mary's Church, Ware, by Miss McNab. With these may be enumerated a large but not quite satisfactory view of the "Interior of Christ Church, Ware," (287) by Miss Taylor. An interior of Rouen Cathedral (220) by Miss Poole, which shows the curious spiral traceried staircase, is open to the same remark. So much for our *professional* criticism. But as it would be uncourteous wholly to pass by the multifarious other subjects on the walls, we will briefly call attention to some which we have noted in the margin of our catalogue. Our first claim is due to the indefatigable secretary, Mrs. E. D. Dundas, who exhibits two interesting sea views, which form a pleasing variety to the rest, which are mostly land scenes. One of this lady's pictures (120) represents "Dysart, Fifeshire," in this early morning and the glow of the rising sun are excellently portrayed; the other is also a Scotch scene, (192) "Entrance to the Kyle Sku, Sutherlandshire," in which, as well as in the former one, every part has evidently been well studied and faithfully delineated. In another sphere of art we must notice (31) "Foxgloves," by Miss Yetts, as especially meritorious; as also a similar study, "Still Life" (166), by Miss James, to which it appears the national medal was awarded. (38) "Fruit," by Miss Gaultier, and the adjoining picture (39) "The fountain," by Mrs. Bridell, are very pleasing productions, while in (45 and 75) we have other beautiful specimens of a like kind, to which are attached the name of Florence Peel. A "Study of trees" (106), by Mrs. Popham, should also be cited; and more particularly (115), by Miss E. Hyde, which, under the title of the "Footbridge leading to Haldon Hall," favours us with a charmingly fresh tree-landscape. (164) A little sketch of "Hadley Common," by Mrs. F. Ouvry, is cleverly washed in, and the distance well given; while a small strip of picture (212), a "View in Northamptonshire," by Mrs. J. Mathieu, is a perfect landscape gem. Of figure subjects we have only space to mention Mrs. V. Bartholemew's striking portrait of Miss Glynn (147), and a clever copy of Dyckmann's "Blind beggar" (now in the National Gallery), by Miss Brimmer.

The collection exhibits altogether 317 pictures and 2 specimens of sculpture.

NEW CHAPEL AND SCHOOL, RIPON, YORKSHIRE.

A chapel and school are now in course of erection at Ripon, for the use of the primitive methodists of the district. The style adopted is Geometric Gothic. They will occupy an area of about 1785 square yards. The chapel is 73 feet long by 45 feet wide, divided longitudinally into three compartments or bays by clustered columns, having moulded bands, bases, and capitals. The height internally from the floor to the ridge of roof is 42 feet, and the height of the walls of the aisles 18 feet. The principal entrance gable has massive and ornamental buttresses on each side, crowned with spirelets of an enriched character, which will be 40 feet in height from the ground level. The materials employed externally are best pressed bricks with stone dressings, the latter being from the Rawden-hill quarries; backed internally with common bricks, to be covered with plaster. The western window of the chapel is 19 feet high by 8 ft. 6 in. wide, and is divided into four compartments, the arched head being filled with elaborate tracery: this window is to be filled with stained glass. There are four 2-light windows on each side of the structure, each alternate one being finished by a gablet with moulded coping. The building will be warmed by hot water. The ventilation is to be effected through the medium of the windows, portions of which are to be constructed to slide. At the eastern end of the chapel is a gallery, having 13 ft. 6 in. projection, for the children. An organ will be fixed on this gallery. Below it are two vestries lighted by 3-light trefoil-headed windows. The school-room is 50 feet long by 25 feet wide, having an open-timbered roof 24 feet in height to its ridge; with walls 13 feet in height. It will accommodate 200 children.

The carvings are being executed by Mr. Beall, of Newcastle-upon-Tyne. The bench ends are to be embellished by sunken quatrefoils and shields. Mr. Gibson Kyle, of Durham, is the architect; and the contractor Mr. T. A. Benson, of Harrogate. The building is arranged to accommodate 600 persons: its cost will be somewhat over £1600.

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GLEANINGS FROM WESTMINSTER ABBEY.*

By George Gilbert Scott.

(*Continued from page* 40.)

The chapter-house is approached from the cloister by an outer and an inner vestibule. The former is entered by the magnificent portal, which you must all so well know, in the cloister. It is a double doorway, the outer arch of which is of two foliated orders; one of them contains in the entwined foliage a series of figures forming a Radix Jesse. The tympanum is exquisitely decorated with scroll-work, and formerly contained a sitting statue (probably of the Virgin and infant Saviour) under a niche, and supported on either side by angels, which yet remain, and the more perfect of which is very beautiful. This doorway was magnificently decorated with colour and gold, traces of which are still clearly visible.

It is in a most lamentable state of decay, but I have, as I trust, arrested the progress of disintegration, by a process which I am largely making use of throughout the interior of the church, and which has already been applied to the wall-arcading and the triforium almost throughout the church, as well as to the majority of the royal monuments. Its effect is to harden and set the crumbling surface, so as to stereotype the work in the state in which it now is. The surface is so tender that we cannot venture to touch it before the operation is performed. We therefore merely blow away the dust with a pair of bellows, with a long flexible tube and nozzle, and inject the solution with a syringe perforated with a number of small holes, so as not to disturb the crumbling surface, which, after the operation, becomes quite hard and rigid.

The outer vestibule is exceedingly low, owing to the necessity for the dormitory to pass over it, to effect its communication with the church. It is vaulted in two spans, supported by small Purbeck marble columns. The bosses of the vaulting are of great merit. The vaulting was till recently mutilated, to allow of a staircase to the room above, now the library; but on discovering and restoring the ancient staircase, which I shall presently mention, I was able to complete this vaulting, and to remove a brick wall which divided the vestibule in its length, and inclosed the marble pillars. On the side which had been inclosed, the ancient paving remains, deeply worn by the feet of the monks. From the vestibule are doorways on either side, the one into the old revestry of the church (now walled up), and the other into a curious chamber, which I shall have to describe.

At the farther end of this vestibule is a second doorway leading into the inner vestibule, which is very different in its design. Being free from the depressing cause before mentioned, it rises to a considerable height, and contains a flight of steps occupying its whole width and leading to the great portal of the chapter-house. It is vaulted in one span, divided into two unequal bays, one of which has contained a remarkable window, now destroyed, but of which, by cutting into the walls, I have been able to gain some clue to the design. On the opposite side are two windows, now walled up, which gave a borrowed light to the altar in the revestry, erroneously known as the Chapel of St. Blaize.

The floor of the chapter-house is probably the most perfect and one of the finest encaustic tile pavements now remaining. It is happily in a nearly perfect state, having been protected by a wood floor. I have thoroughly examined it, and find it to be arranged in parallel strips from east to west, the patterns changing in each strip, though repeated on the corresponding sides. Many of the patterns are most noble in their design, and some of extraordinary delicacy and refinement. The uniformity of the pavement is in one place disturbed by the insertion of a number of tiles containing figures, such as St. John giving the ring to the Confessor, &c. Many of the patterns have been pretty correctly copied by Mr. Minton in the pavement of the Temple Church, and many are given by Mr. Shaw in his recent work on 'Encaustic Pavements.'

Of the external details of the chapter-house scarcely a trace remains; decay and mutilation have brought their work to a final completion. Nor am I aware of any old prints or description which would aid in the recovery of the design. Since writing the above, I have spied out from the window of a neighbouring house a small portion of external tracery, which I had not seen before.

The records are now in great measure removed, and soon will be entirely so. Let us hope that the government will recollect the condition of five centuries back,—that they should keep the building in repair, and that they will give it up to the chapter, with a restoration fund proportioned both to the extent of the dilapidations and the merits of the building. I have omitted to mention that the chapter-house is raised on a crypt, which is vaulted like the superstructure on a central pillar. This pillar is round, and, curiously enough, is carefully hollowed out at two stages, as if for the concealment of valuables. The crypt contains a recess for an altar, with piscina, locker, and the marks of a screen. The crypt was filled up some feet above its natural level with earth, but I have lowered this to the original level. I mentioned just now the two doorways which open (or once opened) from the outer vestibule, and the chambers into which they led. Allow me to describe these chambers.

The one is now mistakenly called the Chapel of St. Blaize; but in the older accounts is denominated the Old Revestry. It occupies a space which is very frequent in abbeys, intervening between the transept and the entrance to the chapter-house, and often called by the expressive name of "the slype." It is little known by visitors to the Abbey; but it is a most picturesque and, as I think, beautiful room, and the skill shown in rendering so irregular a space sightly, and in vaulting it methodically, is very remarkable. Its main approach (now its only one) is the doorway in the centre of the south transept. This doorway, we are told by Dart, was "inclosed with three doors, the inner cancellated, the middle, which is very thick, lined with skins like parchment, and driven full of nails. These skins they, by tradition, tell us were some skins of the Danes tanned, and given here as a memorial of our delivery from them. The doors are very strong, but were notwithstanding broken open lately, and the place robbed." Of these doors one only now remains; but we see the marks of the others. This offensive custom of lining the doors of sacred treasuries with leather, made, not I conceive from the skins of the Danes, but from those of persons executed for sacrilege, was no doubt intended as a means of terrifying less hardened depredators, but was not always effectual.

As this chamber is lofty, and intervened between the dormitory and the church, it was necessary to provide means for the monks to cross it, to get to their nocturnal services. This was effected by a kind of bridge at the west end of the chamber, from which the doorways are still visible which led from the dormitory and into the church, from the latter of which there was a detached winding staircase in the corner of the transept, where now Roubiliac's monument to the Duke of Argyle stands. It is shown in all the old plans, and was probably removed to make room for that monument. The western division of the chamber was clearly the vestiarium. It had in Dart's time, "a set of cranes of wood, swinging, as if in a rack, on which formerly the copes and vestments in common use were hung." There remains still, or did lately, in a forsaken vestry at Aylesbury church, racks of a similar description. In the triforium there is a quadrant-shaped cope-box, probably belonging to the revestry. There are several aumbreys in the walls. The eastern portion was however clearly a chapel; indeed, the vestries of our old churches were generally chapels, as is shown by the piscinæ, almost always, and the altars occasionally, remaining in them. The altar step and some trace of the lower course of the altar still remain. The former has a curious semicircular projection in its centre. Over the altar still remains a full-length figure painted on the wall. It is a female figure, crowned, holding a book in one hand, and in the other carrying, apparently, a gridiron; immediately below it is a small painting of the Crucifixion, and on one side is the figure of a monk in the attitude of prayer, from which, in the direction of the principal figure, are painted the following lines:—

"Me, quem culpa gravis premit, erige Virgo suavis;
Fac mihi placatum Christum, deleasque reatum."

Whether the "culpa gravis" consisted of a disregard of the human hides placed *in terrorem* upon the door, and this painting was the penitential offering of a pilfering monk, I leave others to judge. I have never been able to discover what saint this figure represents, nor the meaning of the badge which she wears. It is on the whole fairly drawn, though unduly elongated, and appears to have been painted in oil. To the south of this altar are the borrowed lights from the inner vestibule of the chapter-house, already mentioned; the adaptation of the vaulting to suit these windows is exceedingly skilful and elegant.

This most interesting room has, unhappily, been long used for

* Paper read at the Royal Institute of British Architects.

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the reception of all sorts of odds and ends, to its great disfigurement and injury. It was there that the ironwork, torn down from the royal tombs at the time of the coronation of George IV., was deposited. Of this I have had the happiness of restoring a considerable part (that to the tombs of Queen Eleanor and of Henry V.) to its place, but some yet remains.

The other chamber I wish to describe is a very different one. It is a low vault, forming an imperfect portion of one of the bays of the Confessor's work already described, and containing a portion of one of the Saxon columns. Within it however is a separate structure of less early date, and long used as a wine-cellar. This inner structure is built up to the old vaulting, but has a low and sloping covering of stone. When I first entered this place I was much perplexed to know its meaning, but after somewhat lengthened consideration, it occurred to me that it was the substructure of the original stairs to the monks' dormitory, which idea agreed well with the existence of a walled-up doorway opposite it in the cloister. I about the same time happened to notice in the manuscript Lives of the Abbots, preserved in the library, that one of them (Abbot Byrcheston) was said to be buried opposite the vestibule of the chapter-house, and near the entrance to the dormitory; a definition of their relative positions which at once confirmed my idea, and at the same time pointed out a walled-up doorway close to the portal of the vestibule as having been the entrance to the dormitory. I obtained leave of Dean Buckland to make an opening in the wall by which the doorway was blocked up, but was at first impeded in my examination by finding that the space within the door was filled completely up with that useful material technically known as "dry rubbish," which, on the perforation being effected, came down like an avalanche into the cloister. After taking out some cartloads we came to the sloping platform, from which, however, I was disappointed at finding that the steps had been removed, excepting a portion of the bottom one, which still remained in its place, and was of Purbeck marble. The sill of the doorway was worn deeply with the feet of the monks, and more so on one side than the other, showing that only one leaf of the folding-doors was generally used. In the dry rubbish were many interesting fragments; among which were some embossed and coloured mouldings, like those in St. Stephen's chapel. This now forms once more the entrance to what was the dormitory, but is now the library.

But let us return for a few moments to the chamber below. On the inner side of the door I found hanging from beneath the hinges some pieces of white leather. They reminded me of the story of the skins of Danes, and a friend to whom I had showed them sent a piece to Mr. Quechet, of the College of Surgeons, who, I regret to say, pronounced it to be human. It is clear that the door was entirely covered with them, both within and without. I presume therefore that this too was a treasury; and I have a strong idea that it then formed a part of, and that its door was the entrance to, the pyx chamber; and it is possible that, after the robbery of the chamber before alluded to, the king finding that the terror of human skins offered no security, remodelled the chamber, and intrusted the safety of his treasury to the less offensive but more prosaic defence of massive and double doors and multitudinous locks.

I have one more tale to tell about this chamber of mystery. There is between the wall which carries the stairs and the wall of the chamber itself a long and very narrow interval, just wide enough to squeeze through. When I gained access to the chamber, now more than ten years back, on going along this narrow crevice, I found its floor heaped up several feet deep apparently with stones and rubbish. While standing on this heap I was puzzled by finding it spring beneath my feet, and stooping down and clearing away a little rubbish, what was my astonishment at finding that I was standing on a large heap of parchment rolls! It proved, however, to be less of a find than I at first hoped, for it consisted mainly of packets of ancient writs from the courts of justice, interesting only from their age, which varied, I think, from Edward III. to Henry VII. There were also a number of fragments lying about of little turned boxes of wood. An unhappy accident intervened. I happened suddenly to be called for a few minutes from this newly-discovered Record Office, and, forgetting to lock the door, a party of Westminster school-boys got in, and, unmindful of the human skins, made free with the parchments. A little disturbance ensued; a fresh padlock was shortly afterwards put to the door, and I have been excluded for ten long years from my treasury, though, as I understood that the parchments had been cleared away, I soon ceased to stand disconsolate at the gate of this dusty Eden.

While preparing the present paper however, I again obtained admission, when, to my surprise, I found my old friend the parchment heap still where I had left it in 1849. I now examined it quietly, and succeeded in turning up a number of the little boxes of which I had before seen the fragments only. They are small turned boxes, of poplar or some other soft wood, not unlike an ordinary tooth-powder box, but a little larger. The covers are sewed on with a leather or parchment thong; and on the underside is usually written a few words describing the contents. On opening them I found that each contained one or more little parchment deeds, with seals affixed; they seem all to relate to the affairs of private individuals, and their great interest is in the earliness of their dates, which vary, so far as I have ascertained, from the time of Henry III. to that of Edward III. They are, many of them, in a perfect state of preservation, in fact, as fresh almost as when new, and are beautifully written, and the seals are often very good. Amongst the parchments were lying fragments of encaustic tiles, of beautiful patterns, similar to some of those in the chapter-house, and the glaze so fresh as to lead one to think they had never been trodden upon.

Since writing the above, the whole mass of parchments, &c. has, by the direction of the dean, been carefully removed into the Abbey Library, where they will be duly examined and cared for. The lower part of the heap was one mass of decay. I have no doubt that they had in former times been carefully stowed away in the space below the dormitory stairs, but had been turned out when this was converted into a wine-cellar; which, by the dates of the lots of wine chalked up over the bins, was at least sixty or seventy years back.

The next work in date to that of Edward I. seems to have been the rebuilding of the refectory, and the completion of the eastern walk of the cloister. Of the former I can find no record. The windows and doorway are of good Middle Pointed character; but of the latter we have a full account in the fabric rolls, showing that it was erected in and about the year 1345, by Abbot Byrcheston. It comprises the rich vaulting over the outer portion of the chapter-house, with the very remarkable window opposite to it, and the adjoining bays as far as the end of this side of the cloister. The vaulting of the principal bay was richly decorated with gold and colour, and the central boss retained at the commencement of the present century the pulley for raising a light in front of the chapter-house door.

The completion of the cloister was commenced in 1350 by Abbot Langham (afterwards archbishop and cardinal), and proceeded slowly but regularly throughout the whole of his abbacy, and was completed by his successor, Abbot Litlington, in 1366, under whose direction indeed, while prior, the previous works had been carried on. We have here again a period of architectural transition. Byrcheston's work of 1345 is the purest Flowing Decorated; but the remainder is very early Perpendicular, so far as we can see, for the tracery is gone from the southern or earlier range. This side we know was in hand in 1355, and one of the two doorways in it (I think the smaller) was inserted in 1358; but even taking the year in which it is distinctly stated to have been completed, 1366, we have a remarkably early date for work distinctly Perpendicular in its character, though of very superior character, and very elegant in its mouldings.

During the reigns of Edward II. and III. it does not appear that the rebuilding of the church was proceeded with; indeed, we find many entries of small sums expended in repairing its windows, &c., and on whitewashing the interior of the old Norman nave. During the reign of Richard II. however the rebuilding was proceeded with. We find entries of the cost of breaking down the old walls, and considerable outlay for stone, marble, labour, &c., and showing that the work proceeded vigorously. About the same period—indeed, commencing in the latter part of the previous reign—most extensive works were here carried on in the monastic buildings. These were for the most part paid for out of a bequest, and perhaps out of previous gifts, from Cardinal Langham, who, as we have seen, had been abbot here, and made the fabric of the abbey his residuary legatee. The works in question were carried out by his very active successor Abbot Litlington, in whose time were erected (besides the south, the west, and the remainder of the north walks of the cloister, which had been commenced in Langham's time) the abbot's house, including its hall and great chamber (the former now used as a dining-hall for the King's scholars, the latter well known as the

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Jerusalem Chamber); the sacrist's, cellarer's, and infirmarer's houses, and a number of other buildings. From this time the nave slowly progressed till the dissolution of the monastery, the west window being finished by Abbot Esteney in Henry VII.'s time, and the western towers left unfinished by Islip, the last abbot worthy of the name. The most remarkable characteristic in these later works is their continuing the general design of the earlier portions, not copying their details as was done in the cloister, but applying details of their own period to the general forms of the preceding age. So that to a casual observer the building presents throughout its interior a homogeneous appearance.

There is one part of the interior of the older portion of the fabric which I have not yet more than cursorily alluded to,—I mean the gallery in which the archives of the church are kept. It occupies the space above that portion of the cloister which passes through the aisle of the south transept. It is approached by a door opening on to the roof of the cloister to the south of the transept. The first bay you enter has, from an early period, been inclosed by timber partitions, plastered over to form a room for the more important muniments. On this plastered partition is a large outline painting of the White Hart, the badge of Richard II., showing the early date of the obstruction; but the other two bays, to form a gallery or upper aisle, open to the church. The details of the upper portions of the aisles may be advantageously studied from this gallery, and on its own account it is worthy of a visit. The shortened columns—that is to say, the parts of them which rise above the gallery—are treated as entire pillars with bases of their own, presenting a singular contrast to the lofty proportions to which the eye has become accustomed. The views into the church from this chamber are picturesque and beautiful in the highest degree. Its contents are highly interesting, consisting of a number of large oaken chests, in which the muniments are deposited. Several of these are evidently of the thirteenth century, and are very curious. There is a handsome trunk of later date in the inclosed space, containing the original indentures of Henry VII.'s Chapel, being agreements with, I think, nineteen different parties (abbots and other authorities), binding them and their successors to see that the rules of his foundation are carried out; but the long-headed king was not wise enough for his generation, for his own bluff son cut the ground from under him, by abolishing the offices which he had made responsible for the performance of his injunctions. I have no doubt that the contents of these ancient coffers would throw much light upon the architectural history of the abbey. The particulars I have given of the works from the time of Edward III. onwards were, by the permission of the Dean and Chapter, extracted a few years since from the fabric rolls by my kind and able friend, Mr. Burtt, of the Record Office, and have been communicated to me while this paper has been in hand.

I will here mention that several of the chests in the pyx-chamber closely resemble those in this muniment-room; so much so, as to make it evident that they also were made in the thirteenth century, and even by the same men. There is in the pyx-chamber another of the same date and higher finish; it contains dies of mediæval coins, and has ironwork of very good character. Others are of different subsequent dates; one of them, made of oak and covered with leather, is very much like that of Henry VII. just alluded to; another is made of deal, and thickly plated with iron. There is among them a very curious leather case, strapped with iron, and stamped all over with fleurs-de-lis, exactly agreeing with descriptions of the cases of ancient documents given by Sir Francis Palgrave. There is also among them another curious leather case, apparently to receive a vessel of some kind.

Having now gone generally through the fabric, I will next advert briefly to some interesting documentary information from the public records, which has quite recently been communicated to me by Mr. Burtt. Of the kindness of this gentleman I cannot speak too strongly. He has, while my paper has been in hand, given himself infinite trouble in searching for notices of the works, and with very considerable success. I am aware that the details of antiquarian documents are not well suited to a meeting like this, and I will therefore only advert to a few important points. The first of them is this. As Westminster Abbey is about the earliest work of its style in this country, and as the building of the first portion of it by Henry III. extended over a space of twenty-four years, *i.e.* from 1245 to 1269, it becomes important to ascertain how early in this period the style of its architecture can be proved to have been defined. Now a single entry in the documents in question has for ever settled this point. I have before stated that the most advanced part of the work as to style is the chapter-house, as that contained traceried windows of four and five lights in a very developed form; the tracery is not confined to circles, but containing great quatrefoils, and the heads of the lights being trefoiled, which is not the case in the church. Now it would be most useful to know the exact date of these windows, for, though Matthew Paris gives 1250 as the year of commencement of the chapter-house, it may have spread over an indefinite length of time, and the windows have belonged to twenty years after that date. Let us look then to the bills. Here we find, in a roll bearing date 37th Henry III., or 1253, and expressly called the eighth year from the beginning of the work, an item of "300 yards of canvass for the windows of the chapter-house," followed immediately by items for the purchase of glass, showing that the windows in question were completed in 1253, which I see was the year before the king, in company with St. Louis, visited the Sainte Chapelle at Paris, which was then scarcely completed, and the style of which indicates exactly the same degree of advancement. I find also, that during the same year the beautiful entrance or vestibule to the chapter-house was erected.

The church itself was by this time—indeed, as early as 1249—in a state of rapid progression, so that the architecture must, in the main, have been quite settled from the time of its commencement.

The entries found by Mr. Burtt are, for the most part, of a somewhat general character; but it is stated in the Pipe Rolls that further particulars have been sent in to the Treasury. These bills of particulars have it is feared been for the most part lost, but Mr. Burtt has succeeded in finding one complete one for about half a year (probably 1253), which is of so interesting a character that there is no doubt that it will be published, with notes by architectural antiquaries. It is a perfect bill of quantities of the work done during twenty-five weeks, giving the names and measurements of every moulding and every detail of the work, and will form a very curious and interesting illustration of the architectural nomenclature of the period. Attached to it are two amusing little letters from the quarry master at Purbeck, promising shiploads of marble, and begging for speedy orders on the ground of other pressing business. The notices I have adverted to in the fabric rolls of the works, from Edward III.'s time onwards, are also very detailed, and give curious particulars as to the mode of employing men at that time. They appear to have been fed and clothed by the employer, and the clothing would appear to be by no means to be complained of. In one year we have an entry of 15*s.* (equal to £8 or £10) for a fur robe for the chief mason; but another year nothing is entered for his robe, because this independent gentleman "refused to receive it on account of the delay in its delivery."

Going back to the earlier accounts, I may mention that extensive works appear to have been going on at the same time in the palace and its chapel, including a great deal of decorative painting; also that the belfry of the Abbey was being built, which I think stood somewhere westward of the church, and of which I believe that some remains existed at a somewhat recent date. The outlay upon the Abbey during the first fifteen years of the work would, if translated into our money value, considerably exceed half a million. I must not, however, follow up these details on the present occasion.

I have dwelt so long upon the fabric that little time remains for any notice of the internal contents of the church. Indeed, they would be more worthily treated of in a distinct paper. I will content myself with a cursory notice of a few to which I chance to have paid particular attention.

That most remarkable work, the Shrine of the Confessor, has been so largely dwelt upon before this Institute, when the subject was brought forward a few years back by Prof. Donaldson, that it would be superfluous to go again into the minutiæ of the investigation, to which I devoted a great amount of time, and was ably followed up by Mr. Burges. I will content myself with a summary of results.

Shortly after my appointment to the Abbey in 1849, I was led, owing to a visit paid to the church by Le Père Martin with myself and some members of the Ecclesiological Society, to devote a good deal of attention to ascertaining as far as possible the ancient form of the shrine; the results of which I gave in a correspondence with a leading member of that society. I removed

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the brick wall which then blocked up the west end, and exposed the marks showing where the altar had been fixed, and came to the conclusion that the pillars now at that end were formerly detached, and carried lights. Probably they were the "feet" which King Henry III. is said to have given for certain lamps to be burnt before the shrine.

The retabulum occupies as I ascertained its proper position, excepting that it has been lifted 3 inches above its original level, a fact proved by its intercepting the space required for the completion both of the ancient and the more modern inscriptions, for neither of which there is now sufficient room. The front and what is seen of the back of the retabulum being decorated with mosaic, and the edge left plain, it follows that the latter must have been more or less concealed. I judge, therefore, that the detached pillars must have been placed very close to them. Mr. Burges has kindly lent me the sketch of his conjectural restoration, which I only differ from in doubting whether there existed more than two of the detached pillars.

Extracts have been kindly communicated to me by Mr. John Gough Nicholls from diaries kept during the days of Queen Mary, showing that the body of the Confessor had been removed, and the shrine wholly or in part taken down, at the dissolution, but restored in Queen Mary's time, when the present wooden shrine, the cornice, the modern inscription and the painted decorations were added. I am inclined to think that the marble substructure was only taken down far enough to allow of the removal of the body, as its parts have been displaced in refixing so far down as that, but no further. The altar either had not been removed or was probably re-erected at the same time, and was, I think, not removed again till the great rebellion, being needed at coronations, on which occasions a table has since been substituted under the old name of "the altar of St. Edward." I found at the back of where the altar has stood a slab, apparently taken from some monument of the seventeenth century, which confirms this idea. There is in Abbot Litlington's service-book in the library, in the initial of the service for St. Edward's day, a view of the shrine, though I fear an imaginary one. The substructure is speckled over to represent the mosaic work, but the seven arched recesses for pilgrims to kneel under, which really occupy two sides and an end, are all shown on one side! The shrine itself is shown lower than was usual, and a recumbent figure of the Confessor is shown on its sloping covering. I will only add, that I opened the ground round the half-buried pillars at the west end, and found them to agree in height with those at the east, which they so much exceed in diameter, and that I have been so fortunate as to recover the broken parts of one of the eastern pillars, and to refit and refix its numerous fragments with the help of one new piece of only a few inches in length, so that we have now one perfect pillar.

In connection with the shrine I will allude to a little discovery which I have shown to many, I daresay, now present. There is a sarcophagus-shaped slab in the floor, immediately to the east of the shrine, which is said to commemorate a son of William de Valence who died young. The cross and inscription are nearly obliterated, but its eastern end is covered by the steps to the tomb of King Henry V. A very pains-taking friend and assistant of mine (Mr. Irvine) in examining the point of junction between the step and the slab, perceived signs of some substance being inlaid into the latter. I obtained permission to remove a portion of the step, when we found that the slab had been inlaid with brass and glass mosaic, and was no doubt executed when the shrine was in hand.

I am enabled by the kindness of Messrs. Minton to exhibit a tracing of a large portion of the pavement before the altar, executed by Roman workmen, and with materials brought from Rome by Abbot Ware, about 1267 or 1268; of the curious inscription a part giving a list of those concerned in the work is still legible, being "Tertius Henricus urbs Odoricus et Abbas." Odoricus being the artist, and "urbs," of course, means Rome, as is proved by Ware's own epitaph, which says, when speaking of these stones, "quos huc portavit *ab urbe*." The tracing was made many years ago for the late Mr. Minton, and under my direction, by my then highly talented assistant, and my now distinguished brother architect, Mr. Street.

It is curious that both in the monuments inlaid with glass mosaic, and in the pavements in which the inlaying material is chiefly porphyry, the artists, as a thing of course, adopted as the matrix Purbeck marble, in place of the white marble they were accustomed to use in Italy.

The tomb of King Henry III. is too well known to need description here, but that of some of his children and grandchildren in the south aisle is but little noticed; indeed, its Italian forms so much resemble those of a modern monument that it usually passes for one.

Taking the tombs of the Confessor, of Henry III. and his daughter, and of young De Valence, in connection with the pavement before the high altar and that of the Confessor's chapel, I should doubt whether—I will not say any church north of the Alps—but I may almost say, whether any country north of the Alps contains such a mass of Early Italian decorative art; indeed, the very artists employed appear to have done their utmost to increase the value of the works they were bequeathing to us, by giving to the mosaic work the utmost possible variety of pattern.

Another object which does not receive the attention it deserves, is the retabulum from the high altar, now preserved in a glass case in the south-eastern aisle. It is a very wonderful work of art, being mostly richly decorated with glass, gold, and painting, and probably with precious stones, and even with casts of antique gems. The glass enrichments are of two sorts—in one the glass is coloured, and is decorated on its face with gold diaper; in the other it is white, and laid upon a decorated surface. The great charm however of the work must have been in the paintings. They consist of single figures in niches of our Lord and SS. Peter and Paul, and two female saints, and a number of small medallion subjects beautifully painted.*

Next to the Italian tombs, one of the most interesting is that of William de Valence. I am not aware whether any old account of this monument exists, but I suppose we may fairly set it down as a French work, and probably executed by an artist from Limoges, though the custom of referring all enamel works to that particular seat of the art is not, I think, borne out by facts; indeed, it would appear from the old accounts that enamels for the shrine of the Confessor were executed here, whether by an artist from Limoges is unknown, though we know that one was employed in England shortly afterwards. The execution of these enamels is truly exquisite, so much so that it is only by the closest examination that any idea can be formed of the wonderful delicacy of the workmanship.

The monument was thus described by Keepe in 1683:—"A wainscot chest, covered over with plates of brass, richly enamelled, and thereon the image of De Valence, Earl of Pembroke, with a deep shield on his left arm, in a coat of mail with a surcoat, all of the same enamelled brass, gilt with gold, and beset with the arms of Valence, &c.....Round about the inner ledge of this tomb is most of the epitaph remaining, in the ancient Saxon letters, and the rest of the chest covered with brass, wrought in the form of lozenges, each lozenge containing either the arms of England or of Valence, alternately placed one after the other, enamelled with their colours. Round this chest have been thirty little brazen images, some of them still remaining, twelve on each side and three at each end, divided by central arches that serve as niches to inclose them; and on the outward ledge, at the foot of each of these images, is placed a coat of arms in brass enamelled with the colours." Since this time the greater part of what is above described has disappeared, showing that the spoliation of the Abbey is not generally chargeable against the rebels, but has gone on in modern times during the contemptuous dominion of Classic taste.

The tomb of Queen Eleanor, with its exquisitely elegant effigy, is too well known to need any description from me. I have had the privilege, since my connection with the Abbey, of promoting the restoration to it of the beautiful piece of ironwork which overhangs it, and which had been removed in 1822. The effigy with that of Henry III. was executed by an artist named Torrell, supposed by Sir Richard Westmacott, I think without evidence, to be an Italian. It is one of the finest which remain in any country.

Were this paper devoted to the monuments alone, I would have attempted a description of the tomb of Edmund Earl of Lancaster, brother to Edward I., and of Aveline his wife. These magnificent monuments, viewed as architectural works, seem to be intimately connected with several contemporary works, especially the Eleanor crosses, and the tombs of Archbishop Peckham at Canterbury and of Bishop de Luda at Ely, all executed between 1290 and 1300. One of their special characteristics is

* An excellent description of this work is to be found in Sir Charles Eastlake's 'Materials for a History of Oil Painting.'

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the extreme closeness with which nature is followed in their foliated carvings, every portion of which is taken directly from some actual plant, with no further conventional treatment than was necessary to adapt it to its position. These works occupy the middle position between the conventional foliage of the earlier and the almost equally conventional foliage of the later divisions of our architecture. It is in fact a mistake to call the foliage, even of the later parts of the Decorative style, *natural*. The use of really natural foliage is very seldom found after the end of the thirteenth and the few earliest years of the fourteenth century, and marks, if I may say so, the resting-place between the conventionalism of *approach* and the conventionalism of *departure* from nature,—the conventionalism of strength and of weakness, of vigour and of lassitude. But the most remarkable characteristic of the two monuments is the splendour of their decorative colouring. The figure sculpture, though possessing considerable merit, is not so fine either as in the nearly contemporary monuments of Henry III. and of Eleanor, or in the somewhat later one of Aymer de Valence. The effigy of Edmund is, however, a very noble and dignified work.

The adjoining tomb of Aymer de Valence is evidently an imitation of those last described, but does not equal them either in its architecture or its decorations, though far exceeding them in the merits of its sculpture. I have seen no old accounts of this tomb, but I fancy that the sculpture is French, both from a decidedly French character in the architectural carving of the niches which contain the statuettes, and from the similarity of the statuettes themselves to some of the same period preserved in the Hotel Cluny at Paris. These, and the effigy itself, rank among the finest specimens of Mediæval sculpture.

The tomb of Queen Philippa stands perhaps next to them in beauty and interest. It is undoubtedly a foreign work, as in the account of its cost still extant it is said to have been executed by one "Hawkin Liege, from France." Its character seems to me rather Flemish than French, and very possibly the artist may have been from Valenciennes, the seat of her father's court. The monument, as you will recollect, consists of an altar tomb of dark marble overlaid with niches of open work in white alabaster. These niches contained thirty statuettes of different personages connected by relationship or marriage with the queen. Nearly the whole of the tabernacle-work, though shown as perfect in the prints of the early part of the last century, has since disappeared. The end of the tomb has been immured in the lower part of the Chapel of King Henry V., and, thinking it probable that the tabernacle-work and statuettes might remain within the inclosing masonry, I obtained permission of Dean Buckland to make an incision into it, which I found could be done without injury to the later monument. I was so fortunate as to find several niches in a tolerably perfect condition, with two of the statuettes quite perfect, and a number of fragments of others. I found also in the tabernacle-work a most beautiful little figure of an angel, with the wings of gilt metal. The figure had lost its head, but I was so fortunate as to discover it enveloped in a lump of mortar. I found also enough of the architectural features to serve as a guide to the recovery of the entire design. Mr. Cundy, the Abbey mason, made from the information thus obtained a restored reproduction of the end of the monument, which he exhibited in 1851. One of the niches and several other portions were afterwards found to be deposited in Mr. Cottingham's museum, and having been purchased from him, have been refixed in their places. One very curious feature in the design is a scroll like the crook of a pastoral staff between the niches at the angles of the monument: the architectural details had no decorative colouring, but the foliage was gilt. The arms were of course coloured, and the figures had beautiful patterns, chiefly in gold, upon the draperies; the hair was gilt, the pupils of the eyes touched in with blue, and the lips with red The head-dresses of the female figures are beautifully enriched with gold and colour. One of the heads was unfortunately broken off while opening it out, for I should mention that the figures were inclosed in a solid mass of rubble work. This head I had a cast made from, and the decoration exactly copied on it. I had also a cast made of the angel before mentioned, and most fortunate it was that I did so. I afterwards most carefully replaced them with my own hands, fixing them in their places with shellac; but though I had told no one I had done so, and though they were quite out of sight, I was disgusted to find, the next time I visited the monument, that both of them had been stolen! They were so difficult of access, that this act of wanton depredation could only have been effected by a person well acquainted with what had been discovered, and that with considerable difficulty. It is most deeply humiliating to think that persons capable of appreciating the value and interest attached to such objects should be so utterly lost to all sense of honour and decency as to perpetrate such a deliberate robbery. I would not go so far as to flay this wretched being, as would perhaps have been done of old, but I should rejoice in the opportunity, according to the figurative expression still extant among our rural population, of witnessing the "tanning of the rascal's hide." If, however, what I have said should chance to meet his eye, let him know that there is still for him a *locus penitentiæ*, and that if he will anonymously restore what he has filched, his baseness shall be forgotten. I should mention that the lost head is so like that of the queen herself, that it is not improbable that it may have been intended for her, though she does not appear in the imperfect list of statuettes given in the old histories. The open work of the niches over the head of the effigy itself has been filled in with blue glass. The magnificence of the entire work may be imagined when it is known that it contained when perfect more than seventy statues and statuettes, besides several brass figures on the surrounding railing.

Somewhat parallel to this, both in material and workmanship, was the monument of John of Eltham, brother to Edward III. I shall not enter into any description of this work however, further than to advert to its beautiful canopy, which is thus described by Keepe:—"A canopy covering the whole with delicate wrought spires and mason's work, everywhere intermixed and adorned with little images and angels, according to the fashion of those times, supported by eight pillars of white stone, of the same curious wrought work." This canopy is shown in Dart's view of the monument, but it was taken down about eighty years back, on the ground of insecurity. It has often been stated that portions of it were preserved at Strawberry Hill, but I have never been able to ascertain the truth of this. If any one should know of the existence of such fragments, I should be truly obliged by their informing me of them.

The original stalls of the choir seem to have been retained in a more or less perfect state till late in the last century. They are shown in the view given by Dart, and in that given in Sandford's account of the coronation of James II. The canopies are shown supported by single shafts. I observed, when the new stallwork was being put up in 1848, that a closet under the organ was lined with old boards which appeared to have formed a part of the back of the ancient stalls, for I could distinguish, by the discoloration of the wood, the form of a trefoiled arch supported by a shaft with a band at half its height. At a later period on looking into this closet I was glad to see the boarding still there; but on looking into it again while preparing this paper, I found that our careful clerk of the works had caused it to be neatly painted, so that this little memento is lost.

There remains, however, in Henry VII.'s Chapel, one of the ancient Early English misereres, and a fragment of another has been preserved. They are both good Early English foliage.

There is a great fund of minor subjects, on which a separate paper could be very advantageously written, but I must leave them unnoticed on the present occasion.* I have gone over my ground as rapidly as I was able, but have more than doubled the allotted time; but Westminster Abbey is at least worthy of an extra hour, and I will only add that I recommend all students of Gothic architecture to devote to it every extra hour they have at their command. London has been pretty much denuded of its Mediæval remains; but, like the sibyl's books, those which remain are worth as much almost as them all; and to live in a city which, amidst its gloomy wilderness of brick and compo, contains so glorious and exquisite a work of original art as this, is a privilege which few other cities could offer us. LET US MAKE USE OF IT.

* Among other things I should have given a description of the Coronation Chair, and of the figures remaining in the panels of the old sedilia, commonly called the tomb of King Sebert. The former is a truly magnificent piece of decoration, but sadly mutilated. The decorations are somewhat peculiar; the whole seems to have been gilt on a thick coating of gesso, and while still soft, the foliage, &c. to have been traced upon the gold, and indicated merely by pricking the outline and the intervals between the leaves. Of the eight figures in the sedilia two only remain perfect. They appear to have been slightly touched up, but are mainly original. They represent, I believe, King Henry III. and King Sebert. The figure of King Edward the Confessor, on the back, which is given by Malcolm in his 'Londinium Redivivum,' can now with great difficulty be distinguished. The painting in the canopy of the tomb of Richard II. ought also to have been noticed. The diapered ground is still very perfect, but the painting of the figures has almost entirely perished.

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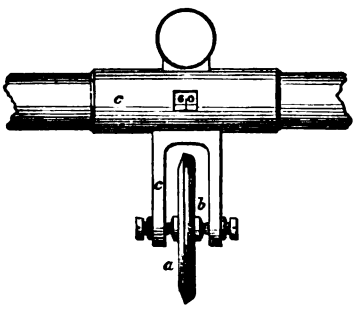
ON AN INSTRUMENT FOR DIVIDING CIRCLES ON PAPER.*

By J. M. Balfour, C.E.

All who are in the habit of protracting surveys of considerable extent, especially if they be marine surveys, are aware that it is often necessary, or at least very desirable, to prick off one or more protracting circles on the paper on which the work is to be laid down. This has been hitherto done either by means of a circular protractor, or by dividing a circle on the paper by means of chords, somewhat after the method of graduation invented by the celebrated instrument-maker, Bird. These methods are however somewhat tedious, especially when the circle has to be minutely divided; and as they are, besides, both more or less liable to inaccuracy, I have been led to adopt the method of graduation which was invented by the late Mr. Edward Troughton, and applied by him to the graduation of his circular dividing-engine and to other important instruments.

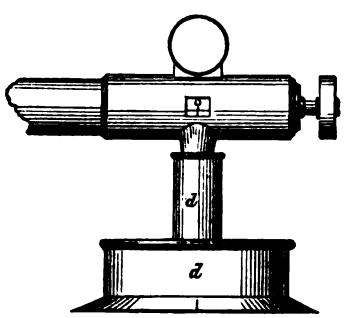
The instrument consists simply of a small wheel *a*, Fig. 1, of thin steel, cut into 90 sharp-edged teeth, though any other number

Fig. 1.



would answer nearly as well; after the teeth are cut, the steel is filed away from one side, so as to reduce the whole to a series of sharp points, every tenth tooth being made with a double point, to facilitate counting. The wheel is then hardened, and attached by screws to a brass disc *b*, to prevent the teeth penetrating the paper too far, and the whole is mounted in a frame *cc*, so as to fit upon a beam compass. The wheel thus mounted is simply Mr. Troughton's dividing-roller, adapted for working on paper, and for marking the divisions at the same time; and all that is further necessary before using it, is to find experimentally the proper radii for which the distance between the points will represent degrees, half degrees, fifteen or ten minutes, or any other quantities which may be desired, and to mark the radii on the beam in a permanent manner.† Of course the influence of temperature will here come into play, but if the roller be set to the radii found by trial, and the instrument run round 180° or 360° on a piece of waste paper, any little error arising from a change of temperature may easily be corrected by the slow motion-screw of the beam. I am

Fig. 2.



aware that, as pointed out by Mr. Troughton, there will be small errors in intermediate quantities, though the wheel turns up 360° accurately, but these errors I have found quite inappreciable in practice, and they are I believe, when the wheel is well divided, much smaller than the errors resulting from graduating circles in the common way. It is also worthy of notice that these are absolute errors, which will not increase with the increase of the radius employed, so that the divisions may be rendered more accurate when required by doubling the radius of the beam, and using only every second mark. In pricking off the divisions it is of importance that the beam be always held in one position, as, if it be more inclined at one time than another, the length of the radius is altered, and I have in consequence found it convenient to have a centre *dd*, Fig. 2, made in such a manner as always to retain the centre point *e*, of the beam in an upright position. The centre *dd* has fine points on its under surface, to prevent it from slipping, and it is divided into four equal parts on the chamfered edge, to facilitate its being laid down correctly over any required point.

This instrument was principally designed to facilitate the protraction of the positions of such soundings as have been fixed by sextant angles, by the method of intersecting circles, and I have found it to answer exceedingly well for the arcs of circles which require to be divided for this purpose. The saving of time thus occasioned is very considerable.

* Paper read at the Royal Scottish Society of Arts.

† The instrument is shown set to mark off degrees.

ON THE STRENGTH OF IRON SHIPS.

By William Fairbairn, F.R.S.

Recent disasters have recalled to recollection numerous defects in the construction of iron vessels, more especially in their powers of resistance to a transverse strain. When we consider the enormous amount of life and property that is at stake, and dependent upon the security of these vessels, it is assuredly a duty to point out the defects in their construction, and the remedies which it is necessary should be applied.

Vessels of a length equivalent to eight or nine times their breadth of beam are subjected, when pitching in a heavy sea, to two distinct kinds of strain. First, when rising on the crest of a wave the ship is supported in the middle with the stem and stern partially suspended; and secondly, when supported at each end and suspended in the middle, as the waves roll under her. In these ever-changing positions it is obvious that her deck, as well as the lower parts of the hull, are subjected to alternate strains of tension and compression; and the tendency is to tear the ship asunder in the middle. That this does take place is evident, from the fact that both wooden and iron vessels have been known to founder by giving way and breaking asunder. Circumstances may at any time arise when the danger from this source becomes greatly increased. The vessel may be cast ashore, and with the receding of the tide may be left suspended partially out of the water, and remain supported at only one or two points in her length by ledges of rock. Such cases have occurred, and it has become doubtful whether our present construction of iron vessels enables them to withstand the shocks and impacts to which in such a case they may be subjected.

This is not the first time I have applied myself to the inquiry, for the purpose of ascertaining, in the first place, what is the transverse strength of vessels as now constructed; and next, whether the builders of iron ships have been guided in their construction by right principles, and have obtained the greatest strength with the smallest quantity of material. In pursuing this investigation, I have come to the conclusion that our present iron vessels are dangerously weak when exposed to strains of the kind I have indicated; and I believe that this defect of construction may be remedied by a more careful attention to correct principles of proportion, without in any great degree increasing the weight of the vessel.

To ascertain the strength of our present ships, I have supposed them to be placed in the extreme position of danger to which they are ever likely to be exposed; that is, supported at the centre of the vessel on some rock, with the ends freely suspended. In this position an iron vessel is in fact a wrought-iron hollow girder, and we may apply the simple formula, $W = \frac{adc}{l}$, by which we ascertain the strength of such constructions.

If we take vessels of the great length of which they are now made, we shall find that they are far too weak along the deck to resist the force of tension to which in the position we have assumed that part is exposed. Taking as an example a vessel of 300 feet in length, built some years ago, I found that she would have given way with four-fifths of the actual displacement of herself and cargo. Taking a vessel constructed according to Lloyd's last rules, and registered A 1 for twelve years, I found her still

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inadequate to sustain the stress to which she would inevitably be exposed in such a position, the weak part being still the upper deck. I am therefore forced to the conclusion, that a large increase in the sectional area of iron in the upper part of the vessel should be adopted; and the plan I have proposed consists in the introduction of two rectangular and two triangular cells of wrought-iron (similar in principle to those in the Britannia and Conway tubular bridges), placed longitudinally under the upper deck of the ship. Cells of this form would increase enormously the strength of that part, and might be adopted without any great modification of the other arrangements of the ship.

In the second place, I am led to recommend the substitution of the new system of chain rivetting along the decks and upper and lower portions of the sheathing, in place of the present weak plan of double rivetting. This change alone would secure an increase of 30 per cent. in the power to resist tension in those parts; and although there are practical difficulties in the way of its adoption, I believe these may to a great extent be overcome.

Now, in looking at the principles on which iron ships have been constructed, it will be found that sufficient attention has not been paid to proportioning every part to the strain it has to bear. As now constructed the iron is distributed almost uniformly throughout the length and uniformly throughout the depth of the vessel, and in this way much material is wasted. In constructions which have to resist transverse strains, economy can only be obtained by collecting the material towards the top and bottom in the transverse vertical section, and towards the centre in the longitudinal section. The longitudinal cells and stringers should be placed as near as possible to the upper deck or the keel, as the case may be, and they should be gradually reduced in thickness from the centre towards the ends of the vessel. With the exception of most of the sheathing plates and ribs, which may be left uniform, no more material should be expended upon the intermediate parts, approaching the neutral line, than is absolutely necessary.

With the adoption of this improved system of construction, and a closer adherence to sound principles of design, I am of opinion that greater security may be obtained, and the fearful accidents which have so frequently occurred be greatly mitigated in severity, if not entirely prevented.

ON THE CONSTRUCTION AND REBUILDING OF THE ROYAL ITALIAN OPERA HOUSE, COVENT GARDEN.*

By E. M. Barry.

Covent-garden may almost claim to be considered by Londoners a household word as far as theatrical associations are concerned, a theatre having existed on the site for nearly a century and a half. The first playhouse of which we have any record was commenced in 1730 and opened in 1733, the distance from the stage to the back wall of the boxes being 54 or 56 feet, which dimensions were then considered large. The theatre was erected to rival Drury-lane, and from that day to the present a constant competition has been carried on between the two great dramatic houses. After extensive alterations, and a partial rebuilding in 1792, the theatre was burnt to the ground. The destruction was complete. The proprietors decided on rebuilding, and secured the services of Sir Robert, then Mr. Smirke, from whose designs and under whose guidance was erected in less than one year the admirable theatre so lately destroyed by the same element which had proved fatal to its predecessor. Sir Robert Smirke's design is so well known that I need not describe it, further than to say that, whatever may be our opinion of the applicability of Greek forms of architecture to the purposes of a theatre, we must all feel that Sir Robert Smirke, while adopting the style fashionable at the time, brought to its execution a thorough knowledge of its capabilities and details, combined with most eminent constructional skill. I mention this the rather because I saw with regret some time since allusions made to bad construction, as evidenced by the use of wood bond in the walls by Sir Robert. Doubtless this is a mode of building very faulty, and now very properly discarded, but as regards the bonds at Covent-garden, they were only on the inside of the walls, and used apparently for convenience in fixing finishings, and as they were only half a brick wide, the strength of the thick walls of 4 or 5 bricks was but slightly diminished. In all other respects the construction of Sir Robert Smirke's theatre appeared to me to be excellent, and the arrangements of arches and voids, piers and footings, were such as might be most advantageously studied by the architectural student; while the great thickness and solidity of the walls were such, that in removing them the contractor for the excavations often found many reasons to wish their construction had been of a less permanent character. The first stone of the new theatre was laid on the 31st December 1808, by his royal highness the Prince of Wales, and a brass box, containing a bronze medal with the prince's portrait upon it, and a selection of the current coins of the day, was placed under the foundation stone at the north-east corner of the building, where it was found by the workmen engaged in removing the ruins. The theatre was opened on the 18th September 1809, having occupied only 8½ months since the laying of the foundation stone. The cost of the building was I believe £180,000. The theatre was used for English dramatic representations until a few years ago, when it was determined to convert it into an Italian Opera House. To carry out this resolution, extensive alterations were required, both as to the form and size of the auditory, and they were placed under the professional guidance of Mr. Albano, who gutted the audience portion of the theatre, and rebuilt it according to his own designs. Mr. Albano's alterations consisted of an enlargement of the auditory, both longitudinally and transversely, and of some modifications of the entrances and staircases rendered necessary thereby. The fate of so many theatres however soon overtook Covent-garden, and in March 1856 it was burned to the ground. The subject of fireproof theatres is one well deserving the attention of members of our profession. At present, so regular a fate appears to hang over these buildings, that it is almost considered a matter of course that they should be burnt down. The fires at Covent-garden have been already alluded to. Drury-lane was burnt down in Februry 1809, not more than five months from the destruction of its rival, the King's Theatre (as Her Majesty's Theatre was then called), which was burnt down some years before; and Astley's, the Strand, the Olympic, and I think some others, have been burnt down in our own times. The peaceful pulling down of the old Adelphi to make room for its present graceful and commodious successor is an event not often paralleled in theatrical annals. Those who have had opportunities of inspecting the working of theatres can be at no loss to account for their danger; but though much peril might probably be removed, there are few places where innovation is less welcome than within the walls of a theatre, and many prejudices will have to be removed, and many novelties introduced, before the public can possess a place of entertainment absolutely fireproof, although much may be done, and in fact has been done both at the New Adelphi and Covent-garden, to reduce the danger and to protect life.

Before describing in detail the construction of the several parts of the new building, it may be useful to glance at the general principles which guided its arrangements, and in some measure determined its design. After so dire a calamity as that which had just befallen its predecessor, it was but natural that it should be sought to render such a catastrophe less likely to occur. It was consequently determined to carry out a system of fireproof construction wherever practicable, and though it is perhaps hardly possible at present to render a theatre actually fireproof, the new building was intended to be an advance in that direction. The Building Act most properly requires all corridors and staircases in such structures to be of incombustible materials; and these requirements had of course to be observed. In addition, as it had been noticed in previous cases of fire that the roof served as an easy means of connection between the stage and the auditory, it was sought to avoid this source of danger by making the roof and its covering entirely fireproof, and it was decided to use wood as little as possible in the construction of the interior. Regarding the danger of staircases with well-holes in public places (which has since received a lamentable illustration in the case of the Polytechnic), all staircases used by the public were arranged to consist of solid stone steps built into a wall at each end; there were to be no windows, and the well-holes were to be filled up by walls carried up from the bottom, after the custom so common in Italy, and which, from its advantages to the stability of the edifice, as well as to the safety of its occupants, appears to be well deserving the attention of architects who have to provide for the reception

* From a paper read at the Royal Institute of British Architects.

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of large crowds of persons liable to sudden panics. The shape of the auditory was a matter of much consideration. The faults of a horseshoe shape being obvious as regards the position of the side boxes, plans more or less approaching to a circle or ellipse were tried and laid aside, and different schemes of arrangement canvassed. The result was, that the horseshoe form was at length resolved on, notwithstanding the disadvantages above alluded to. The requirements of a London theatre for the Italian opera are very peculiar, and differ in many ways from those of ordinary playhouses. As regards the latter, the great desideratum is of course that all the visitors may see and hear to the greatest possible advantage, and so that this be achieved, the relative position of the audience to each other is of comparatively small consequence. In an opera house, though similar objects are sought to be attained, there are other circumstances to be considered, which in some measure counterbalance them. Thus, the Royal box being on the grand tier, the latter is the great resort of fashion, and inasmuch as the rent of the boxes on the grand tier bears about the same proportion to the tiers above that a drawing-room floor does to a first floor, it is obviously a great desideratum to obtain as many boxes as possible in this level, where it is found that even the side boxes (in spite of drawbacks of position) are always eagerly sought for. The system of separate boxes likewise prevents the possibility of gaining accommodation by deepening the dress circle, so as to get several rows of seats. For these and other reasons it was considered that, assuming the dimensions of the proscenium to be fixed at 50 feet as the maximum admitting of convenient working, a horseshoe more or less elongated was the fittest form in this particular case, although it might possibly be modified with advantage in other structures with less peculiar requirements. The alleged acoustical advantages of a horseshoe plan were likewise supposed to have some weight, and certainly Her Majesty's Theatre is an encouragement to any architect to adopt that figure, as it is unquestionably most successful in this respect. In order to illustrate the difference of shape, I have had prepared a plan of Her Majesty's Theatre to the same scale as the other places before alluded to. It will be perceived that in the old theatres the Royal box was on the left-hand side of the auditory, and that in the new house it is placed on the opposite side. It will readily be seen that, as regards Covent-garden, facility of access from Hart-street governed this arrangement, which, as it involved a departure from time-honoured precedent, was submitted to Her Majesty for approval before the building was commenced.

Another peculiarity of plan in the new theatre may here be noticed, as regards the crush-room or saloon. This is situated at the top of the grand staircase, and forms an ante-room, through which all must pass on their way to the boxes. The refreshments are placed at the further end of the room, instead of being in a separate saloon, inaccessible to ladies. The object sought by this arrangement was, by rendering a passage through the crush-room imperative to all, to cause it to be forbidden to none; and the result has fully answered the expectation, inasmuch as all classes of spectators may now be seen to resort to this apartment for refreshment between the acts or during the performances.

It may be observed on examining the plan, that owing to the shape of the site the building is not rectangular, the corners in Bow-street being respectively obtuse and acute. By constructing the principal entrance from the crush-room not in accordance with the centre line of the auditory, facilities are obtained for the formation of a grand state box in the centre of the house, on special and extraordinary occasions, by taking in the boxes on either side and the corridor in the rear. The iron beams over the centre boxes are fixed with bolts and nuts instead of rivets, to allow of their removal on such occasions, so as to give to the state box the additional height which its importance would demand. Entrance to the state box would probably be obtained by the g and entrance for the royal party and suite, and the public could be admitted from the Floral Hall, from Hart-street, and through Her Majesty's ordinary private entrance. It will not escape observation on comparing the plan of the new theatre with that of its predecessor, that although the dimensions both of stage and auditory are larger in the former case than in the latter, the size of the whole building is less at present than was the case formerly. This reduction of size was caused by the determination to devote the southern portion of the site to the erection of a building of iron and glass, to be called the Floral Hall. Inasmuch, however, as a large stage and auditory necessarily require adjuncts of appropriate capacity, it became obvious that the only way to make up for deficiency of area was to increase the height. There are eight stories of rooms on either side of the main building, and in these are placed the green-room, the dressing-room, lavatories, wardrobes, armouries, music rooms, private sitting-rooms, and the numerous other apartments necessary for the working of a large lyrical establishment. In addition to the space obtained by the above arrangement, it was considered that important structural advantages were gained by carrying up the side buildings to the same level as the principal walls, instead of having the latter isolated for their upper portion, as is the more common arrangement. Regard being had to the well-known strength of hollow columns, it was thought that the arrangement adopted of two longitudinal walls 11 feet from each other, and connected together by frequent cross walls, would possess all the advantages of a series of rectangular columns or piers, if the tenacity and cohesion of their parts could be effectually secured. In good brickwork, when perfectly set, this would necessarily result, but as in the case under notice the building required to be occupied before the mortar was dry, and the roof and other great weights would come upon the green walls almost before the bricklayers' scaffold could be removed, it was determined, as a temporary measure, to assist their cohesion by iron ties passing through the cross walls, and connecting together the two main longitudinal walls. These were inserted about every 12 feet in height, and were each composed of 2-inch square rods, placed 9 inches from each other, so as to avoid the flues, and secured at the ends by screws and nuts to strong iron plates. These ties have now served their purpose, and the walls being thoroughly dry and the mortar set, are independent of extraneous assistance. The arrangement and design of the roof called for some consideration. It is customary to place the carpenter's and other shops in this portion of the building, and the ordinary plan is to construct the roof with queen-truss principals, so as to get as much accommodation as possible between the queen-posts. The truss used by Sir Robert Smirke was of this description, and deserves the most attentive study as a piece of careful and excellent carpentry. From what has been said as to the comparatively small area covered by the new theatre, the importance will easily be seen of gaining as much accommodation as possible in the roof, and it soon appeared that a system of beams passing from wall to wall, with small roofs between, offered peculiar advantages as regards space when compared with the limited area allowed by the queen-truss arrangement. The iron beams supporting the roof are 96 feet long, and 9 feet deep, and the credit of this design is due to Mr. Henry Grissell, who undertook to make, fix, and guarantee them. The beams are of the description known as trellis, in eleven compartments. The flanges are composed of a combination of angle-iron, wrought-iron plates, and a section which may be called double L iron. The diagonals in compression are composed of double angle beers, each 6 inches by 3 inches, and the diagonals in tension are formed of double flat beers varying from 7 inches by ½-inch to 7 inches by ¼-inch. It was considered that the open box form of the upper and lower flanges would give a considerable amount of lateral stiffness to the girders, and that by the adoption of the trellis form a lighter and more convenient girder could be obtained than by using one with a solid web plate. The necessity before alluded to, of using the roof as workshops, determined the depth of the girders, which it was found could not be less than 9 feet without causing inconvenience to the workmen, and the facilities of passing through the girders, wherever necessary, was also thought a desideratum. The accessibility of the various parts of the girder to the painter's brush was also obtained, a great point where wrought-iron is used, and the importance of which, considering the great tendency of this material to rust, is perhaps hardly always sufficiently recognised by us in practice.

There are eight main roof girders, 21 feet apart, and on the top of each is a cast-iron gutter 16 inches wide; wrought-iron principals of the usual character, and 21 feet span, connect the girders together and support longitudinal purlins of T iron, and the whole is covered with slab slate ½-inch thick, with laps and fillets constructed in the ordinary manner. The workshops are lighted by skylights in the apex of the roof, all of which, with the exception of the necessary woodwork of the skylights, are thus of an incombustible character. The girders occupying the whole side of the workshops, it became necessary to consider how large pieces of framing made in the shops could be lowered to the stage, as the interstices between the vertical struts and diagonals of the girders could only allow pieces of small size to pass

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through them. The object was sought to be attained by fixing the girder immediately over the proscenium, its own depth lower than the others. Advantage was taken of the necessity for a sound reflector at this portion of the ceiling to effect this, and the top of the girder over the proscenium is level with the workshop floor. On the top of this girder two cast-iron stanchions are fixed, carrying intermediate girders and the roof, and three spaces 25 feet, 40 feet, and 25 feet wide are thus left open to allow of the passage of bulky articles. The girder at the stage end of the building is 30 feet from the wall, and the space between is covered by a lean-to roof, also of wrought-iron, with a large skylight over the painting room. A lean-to roof was here adopted from its giving the maximum of height to the wall on which the painting frames hung, and from its readily allowing abundance of light to fall at the proper angle on the same. There are no floors between those girders which are over the stage, and the scenes can therefore be raised as high as the tie-beams of the 21-feet span roofs. The weight upon the girders is, as may be supposed, very large, and the mode in which it was calculated may be seen by the table annexed, which shows a weight of 150 tons to be provided for as regards each girder. Before any were fixed, the completion of two was hurried on at Mr. Grissell's works; and when finished they were placed side by side on his wharf, and loaded with 300 tons. Special foundations were formed of concrete, and the girders placed about 9 feet apart, on balks of timber resting upon brickwork and concrete. Cross-pieces of iron were introduced between the girders to act as stays or braces, and to serve the office rendered in execution by the transverse roof principals and floor-beams. The preparations being completed, pig-iron to the amount of 300 tons was heaped upon the girders, an occupation which consumed several days. The girders were constructed with a camber of 2½ inches, and when the weight was on a deflection of 1⅞ inch was observed. On the removal of the weight a permanent set was found of ⅝-inch in one girder and ¼-inch in the other—a result probably attributable to all the parts having been brought to their bearings. It had been my intention to have allowed the weight to remain upon the girders for 10 days, but after it had been on for 24 hours, signs of weakness appeared in the wharf wall adjoining, and it was found that unless this was quickly relieved, girders, foundations, and wall bid fair to find a resting-place in the Regent's canal. The pig-iron was therefore removed in all haste, but the result of the proof was considered so satisfactory, that the whole of the other girders were constructed like the two first, without any alteration. During the week before last I again tested one of the roof girders, to ascertain whether two years of work had produced any effect; I found the camber reduced to 1⅜ inch, showing a set consequently of ⅞ of an inch.

Estimated Load on Main Roof Girders.

	Tons	cwt.	qr.
Ten iron principals of intermediate roof	1	10	0
Eleven bags of iron pantries	2	3	0
90 feet cast-iron gutter	1	8	0
1980 feet super. of slates at 8 lb. per foot ...	7	1	1
Ditto ditto snow, 10 lb. per foot ...	8	16	3
Effect of wind	11	18	2
Eight transverse girders for floor	4	10	2
Wooden floor and joists	8	0	0
1800 feet of lead at 100 lb. per foot ...	80	7	0
Contingency for ceiling, &c.	7	5	0
Trellis girder itself	17	0	0
Total distributed load on each girder ...	150	0	0

Some peculiarities of construction resulted from the determination to render the theatre available for other purposes than those of the Italian opera. The arrangement of the theatre for the latter is so peculiar, owing to the special requirements before alluded to, that it is not suitable for other performances without considerable modifications. In rebuilding the opera-house however, Mr. Gye resolved that it should not be erected with a view to one destination only, and it therefore became necessary to consider how his wishes could best be carried out. The boxes being entirely supported by iron beams, cantilevers, and columns, the divisions between them are formed of 1½-inch wood framing, and are all moveable. The backs of the boxes are likewise capable of being removed, so that a portion or the whole of the corridor may be taken into the boxes if required, to form an extended dress circle. On the pit tier, the boxes, with the floors, fronts, sides, and backs, can be entirely taken away, giving facilities thereby for forming a very capacious pit, extending under the dress circle to the semicircular wall at the back of the corridors. The entrances to the theatre are so arranged that they are suitable for this arrangement of the auditory without modification, and the whole of the pit floor is so constructed that it can be raised or lowered at pleasure in a few hours.

The first brick was laid on the 23rd of September 1857, but it was not until the end of October that the whole site was available for the energetic prosecution of the works. Almost all the ironwork, however, was ordered before the footings were completed, and the roof was in consequence furnished and ready for fixing before the building was more than three parts up. Considering the unfavourable period of the year, and the risk of interruption to the bricklayers by rain, it was resolved to try to obviate this kind of delay if possible. Messrs. Lucas, directly the matter was named to them, agreed to furnish all their men with complete suits of waterproof clothing, consisting of coat, leggings, and hood; and the men, while working on the walls in this black-hooded costume, reminded one of nothing so much as the story-book pictures of familiars of the Inquisition. It was soon found however that the walls, being built in mortar, could not be prudently carried up during severe rain, and the waterproof contrivances were therefore only used very occasionally.

It will be seen that the arrangements for the auditory are quite independent of the external walls, and the boxes and corridors are, in fact, a separate structure of iron, stone, and wood, erected inside the chamber formed by the many walls of the building. For reasons already adverted to it was resolved to use iron for this portion of the work; and it may be remarked that wrought-iron has been adopted for almost all portions of the construction exposed to danger from fire and severe tensile strains, in consequence of its presumed advantages over cast-iron in such cases. The boxes are supported by wrought-iron cantilevers, formed of two pieces of T iron 5 by 5 by ½. These are connected together with connecting web-plates, so as to form a double T, one piece serving as the upper flange and half the web, and the other constituting a lower flange and the completion of the web. A specimen beam was made before the works commenced, and carefully tested by actual weights before its application was resolved upon. The floor of the corridor is formed of 3-inch York landings, rubbed on both sides, which thereby form at small expense both floor and ceiling. They are supported on rolled iron joists, connecting together the cantilevers before described, which are strongly let into the wall of the corridors, and have a point of support distant rather more than half their length on cast-iron columns placed at the backs of the boxes. The columns are eight in number, in sets of four, resting on each other, being carried up from the basement. In consequence of the necessity for the cantilevers to pass through the columns at the points of support, the top of each column is formed into a species of box, through which the cantilevers pass, and to which they are safely secured. It will be seen that as the columns rest on each other they cannot yield to superincumbent weights unless their foundations give way. It was, therefore, felt to be a difficulty that, while the walls would certainly settle—especially when carried up so rapidly—the columns, by remaining rigid and unyielding, would probably cause serious inconvenience, and might, by altering the levels of the cantilevers and beams, expose them to aggravated cross strains. To obviate this danger, it was resolved not to fix the ironwork until the walls were carried up, so as to give as much time as could be afforded to allow them to settle. It was also determined to make the boxes forming the heads of the columns rather deeper than was necessary. The bearing was then brought up to the right height by their filling in pieces of sheet-iron, any number of which might be easily withdrawn in the event of the walls settling, and requiring a corresponding lowering of the beams and cantilevers. It is satisfactory to add that these precautions have never been called into play since the ironwork was fixed, nor has any settlement occurred, as far as I know, since the completion of the building.

The number of bricklayers for some weeks exceeded a hundred, and the number of workmen of all classes varied from a small body at the commencement to as many as 1200 during the last few weeks of the works. The joiners' work was prepared at Messrs. Lucas's works, at Lowestoft; and all the principal portions of it were put in hand at the same time that the brickwork was commenced, and all difficult parts were carefully put together on the premises, then and there carefully taken down, marked, and sent to London. Thus the ceiling over the pit, the combined curves of which needed some care to insure accuracy, was put

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together and temporarily supported in Messrs. Lucas's yard many weeks before the building was ready to receive it. Owing to the limited space occupied by the building, the site of the Floral Hall being still encumbered by ruins which there had been no time to clear away, much difficulty was experienced in finding room for the large quantities of materials daily required; and when the time came for delivering the great roof girders, 96 feet long, 9 feet deep, and weighing 17 tons each, it became necessary to hire a wharf on which they might be stored until they could be received and fixed. The girders were divided into halves for convenience of transit, and in that form were eventually brought to the works.

Considering that the walls, 85 feet high, had been carried up in thirteen weeks, and during an unfavourable time of year, precautions were thought necessary to insure as far as possible an even distribution of weight upon them, which was rendered the more necessary from the fact that, owing to the peculiar construction of the roof before adverted to, the main girders had not only to carry their own weight and the weight of the roof, but were also required to support the ceiling of the auditory, the scenic arrangements over the stage, and a complete story of workshops. In the old theatre Sir R. Smirke had effectually provided for distribution of weight by placing two wall-plates of nearly whole timber dimensions along the walls; but with an iron construction this resource was of course unavailable, while the iron girder was not only heavier than the wooden truss, but was also nearly one-half further apart from its neighbour, thus adding in every way to the necessity for precaution from the greater concentration of weight on certain points. The mode adopted was, instead of using wall-plates of wood, to carry up twelve courses in cement and hoop-iron, forming thereby a wall-plate of brick and cement. This 3 feet of wall was connected with the external and cross wall by iron ties similar in character to those before described, and from it six more courses also in cement were carried up to the underside of the templates which receive the main beams. These are of stone 4 feet by 3 ft. 9 in., and upon them are fixed cast-iron plates 2 inches thick, carefully fitted to the shape of the lower flange of the beams. These iron plates were found very useful in fixing the beams in their places, as will be seen presently. The operation of hoisting and fixing the main roof-girders was a matter of some difficulty, and several modes of accomplishing it were considered.

It may, perhaps, be interesting to describe shortly the manner in which these great metallic principals, each weighing 17 tons, or more than the unfortunate Big Ben of Westminster, were safely fixed in their places. It was felt that, considering the greenness of the walls, and the absence of cross walls, a sudden blow from any accident in hoisting the girders might be attended with very serious consequences. Moreover, the length of the girders being 96 feet, and the space between the walls only 90 feet, it was obvious that they could only be hoisted in an oblique position if raised whole, and such a course would entail great difficulties in getting them into their permanent places on the top of the building. It was consequently determined to raise them in two pieces, in which condition they came to the works as before stated, and to rivet them together on the top of the building. In a central position, where the proscenium now stands, a scaffold, about 30 feet by 20 feet, was raised, and floored over at the same level as the top of the walls. The half girders were then raised and placed temporarily, so that the two ends rested on the walls, and the divided centre portions were supported on the scaffold, which resembled a gigantic table. Small portable forges were then supplied on the scaffold, and the half girders were rivetted together in the position described, the whole operation taking about three days to effect. The girder then required to be moved to its place, and room made for the others. Great caution was used in moving the girders, to avoid exposing them to any severe cross strains, which by deranging their parts might materially injure them. It was necessary therefore that the girders should be moved evenly and easily, both for their own sakes and by reason of the state of the walls. To effect this a whole timber was laid upon the walls longitudinally, and an iron rail fixed on the top of the same. Carriages, with flanged wheels running on the rails, were placed under each end of the girder, and a very moderate force applied to the carriages caused the great mass to move along the walls with the ease and smoothness required. As soon as a girder was moved from the scaffold another took its place, and before the latter was rivetted a third was hoisted, ready to occupy the scaffold as soon as vacant. Thus the three operations of fixing, rivetting, and hoisting were all pursued together by different gangs of men.

We have now accompanied the girder to its place, but we have not yet seen it placed in its permanent resting-place, to do which without a jar to the walls, and with perfect accuracy, was an operation requiring some delicacy. As the whole roof is so connected together both with floor beams and roof principals, all of which were made at the same time as the girders, and were fitted to them to the twentieth part of an inch, any even trifling inaccuracy in fixing the girders would have produced serious difficulties. The iron bed-plates under the ends of the girders were therefore fixed in the stone templates with great care; they were provided with a hole through them under the centre of the girders, tapped for a 2-inch screw, and a corresponding hole was drilled through the stone template. Several courses of the brickwork under the stone template were also temporarily left out. The screw was then introduced from below, and passed through the carriage under the end of the girder, which was carefully adjusted directly over the screw. The carriages were then removed, and the girders left resting upon the screws, which were then slowly withdrawn from below, and the girder finally lowered to its resting-place. The omitted brickwork was then made good, and the fixing was complete as far as the main girders were concerned. Care was taken not to surround the ends of the girders with brickwork, but to have them free, and susceptible of being painted from time to time. The small intermediate roofs having been all prepared before, were next fixed with great rapidity, and the roofs at the ends of the building were slated and covered in before the girders for the middle portion were even hoisted—the whole operation of hoisting and fixing the girders having taken only three weeks. The floor-beams between the girders over the auditory were likewise soon in their places: they are made of wrought-iron, and carry the floor of the workshops and the ceiling of the theatre. The chandelier is supported by two iron beams, supported at each end by the main trellis girders. It is worked by a crab, and can be raised partially into the workshops, or lowered to the floor of the pit.

As soon as the floor was completed as described, the internal works of the building were pushed forward as much as possible, and the interior of the auditory, which was at present only in carcass, began soon to assume its present shape. It being naturally of the greatest importance to employ as many hands as possible, it was decided not to allow any scaffold to be erected from the ground, but to construct the ceiling from a platform suspended from the iron beams of the roof and the floor in the same. The platform was constructed in the following manner:—rods of wrought-iron 1 inch in diameter were hung down from the beams above, where the aperture in the centre of the ceiling would ultimately be formed. From this point timber beams or joists radiated like the spokes of a wheel, each beam or spoke being supported at one end by one of the iron rods above alluded to, and the other end being carried by a rope strongly fixed to the beams of the floor above. These radiating beams, thus constructed, formed the supports of a platform on which the necessary scaffold was erected for the fixing and completion of the ceiling. The latter is covered with Bielefeld's fibrous slab, which has been extensively used at the British Museum. It was fixed in large slabs about 12 feet by 6 feet, and is ¼-inch thick. Of course, in covering the ceiling, it became necessary to shift the ropes supporting the scaffold to such positions as would not interfere with the decoration, or cause unsightly holes to be made through the slabs. Provision was accordingly made for the existence of some holes in the ceiling, through which the ropes might pass, not only during the progress of the work, but also at any future time when repairs or re-decoration might be necessary. The holes, twenty-four in number, are placed at the joints of the fibrous slabs, and are concealed in the finished ceiling by plugs let down and removeable from the floor above, so that ropes may be at any time lowered through them, and a scaffold formed with facility, and at slight expense, whenever required. The form of the ceiling is as follows:—over the pit is a flat dome, 65 ft. 1 in. diameter, and 7 ft. 2 in. high; this rests upon four elliptical arches 63 ft. 7 in. span, with pendentives. The ceiling over the main gallery is flat, and the two side galleries or slips are covered with arched ceilings, following the shape of the elliptical arches supporting the dome. The dome is formed of purlins in two thicknesses, circular in plan, and hung down from the floor above by wrought-iron rods. The purlins carry ceiling joists in the ordinary

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manner. The arch nearest to the stage is 10 feet from the curtain, to allow of the formation of a sound reflector over the foot-lights and the projecting piece of stage from which the principal *artistes* commonly sing. The reflector is curved, and follows the form of a parabola. It displays for its ornamentation a bas-relief, designed by Signor Monti, representing the ancient and modern drama, with a likeness of Her Majesty in profile between the two subjects. The box-fronts were also designed by the same artist, and are executed in the new combination of canvas and plaster which Mr. Owen Jones has largely used, and has lately introduced to the notice of this Institute.

The decorations of the interior were for the most part carried out under the personal directions of Mr. Gye, assisted by Signor Monti, only a small portion of the original designs for this portion of the work having been carried into effect. The whole of the operations connected with the ceiling, such as fixing the carpenters' work, fixing and painting the fibrous slab, and fastening the enrichments in their places, were carried on from the suspended scaffold, and during this time the works below were being pushed on with all despatch. The foundation walls under the pit were built, the iron columns and cantilevers for the boxes were fixed, and carpenters, masons, smiths, painters, decorators, and gilders, jostled each other. Indeed the interior of the theatre at this time presented an epitome of the building trade, almost every handicraft having its numerous representatives, while the placards in the streets, announcing in large letters the 15th of May as the day of opening, were calculated to cause all concerned the greatest anxiety.

In designing the construction of the floor to the pit, a question arose which determined its general character. With a view to render the theatre applicable to all possible purposes, it appeared to be an advantage to possess the power of raising or lowering the floor if required. On such occasions as public dinners, balsmasqués, &c., it is obvious that such a facility might prove very advantageous. It was accordingly resolved to support the floor on trussed timber beams, 2 ft. 3 in. deep, resting on cast-iron columns. These columns have split heads, resembling a musician's tuning-fork. By the adoption of this form the trussed floor-beams can be lowered into the columns their own depth whenever required, a number of packing-pieces filling up the cavity in the top of the column if it be desired to retain the beams at any particular height. An instance of the convenience of being able to alter the position of the pit-floor was shown soon after the opening of the house. From some misconception, the stage had been fixed 9 inches too high, and the occupants of the front rows of stalls had an impaired view of the performers in consequence. During the recess the front portion of the pit floor was raised 9 inches, so as to occupy its proper relative position to the stage, and the inconvenience was at once obviated.

While the works above described were in progress, the stage was in active preparation. Mr. Beverley, the distinguished artist, was consulted as to its general arrangement and mode of working, and the practical realisation of his views was confided to the experienced hands of Mr. Sloman, who has been so long connected with the theatre, and whose reputation in such matters is so well established. The proscenium columns are arranged to slide on wheels, so as to expand or contract the opening when desired. The grooves so commonly used for the support of the scenes are entirely done away with, it being considered that their undoubted convenience is more than counterbalanced by their attendant disadvantages, and more particularly by the obstacles they afford to the formation of a grand open scene embracing the whole extent of the stage. The back scenes are of single sheets of canvas, lowered from the top and secured to rollers resting ultimately on the main beams of the roof. The side scenes and set pieces are fixed to the wing ladders behind which the side gas-lights for lighting the stage are placed. The wing ladders being unattached to anything above, the artist is enabled to place large set-pieces, such as trees, rocks, houses, &c., against them, and still preserve the total height of the stage, while they are so constructed that they may be moved completely across the stage. The upper pieces of scenery, known technically as borders, are of somewhat novel construction. Owing to the great size of the stage, it was desired to possess the power of using it to its greatest width, especially for out-door scenes, and I may perhaps mention some of the scenery in *Dinorah* as instances of how admirably Mr. Beverley can use his opportunities: but borders to suit such extended scenes would be useless for those of a more limited description, and to avoid the necessity for a double set of scenes, it was resolved to make the borders in three pieces—a centre and two wings; the latter being so arranged as to slide forward and back, so as to form an area of any required diameter. There are two sets of flies, 8 feet wide, from which the machinery is worked, and there are recesses on each side of the stage to receive the scenery not in use. One of these recesses is occupied by a powerful organ, often used as an auxiliary in operatic performances.

The painting-room occupies the ordinary position at the back of the stage; but as the floor is carried by a trellis girder of the same description as those supporting the roof, the stage is enabled to extend entirely under the painting-room without interruption from walls or columns. The painting-room is 90 feet long by 30 feet wide, and 50 feet high in its highest part. It contains several painting-frames of different sizes, hung in pulleys fixed to the walls, and furnished with counterbalance weights. The frames are contrived to slide downwards through the floor, so that the artist can readily gain access to any part of the canvas he may desire, without leaving the floor of the painting-room. There is a large skylight in the roof, and the floor is furnished with traps to admit of moving scenery to or from the stage below. The scenes being necessarily often of a very large size, owing to the great dimensions of the stage, slits are provided in the stage floor under those already described in the floor of the painting-room, so that the scenes may be lowered even as far as the basement, if required. Under the floor of the painting-room are fixed the contrivances for simulating the noise of thunder, rain, and the like; and the great bell, whose mournful notes have sounded the knell of many a disconsolate tenor, is fixed in the same position.

The new theatre being intended to be used principally in summer, it was not considered necessary to do much in the way of warming as far as the opera season was concerned; but with a view to its occupation in the winter—as is now in fact the case—some artificial means of warmth were nevertheless required. A chamber is consequently placed under the pit, sufficiently low to admit of the lowering operation before described, in which hot-water pipes, heated from an apparatus under the grand staircase, are fixed; an air grating round the pit allows the heated air to escape into the house. The principal exit for the heated and vitiated air is through the aperture, 10 feet wide, over the chandelier; above which there are openings into the external atmosphere. There are air-valves to the boxes over the doors, and a number of small holes are drilled in the risers of the gallery seats, giving a passage for the air from the halls and corridors to the chandelier, but not in sufficient quantities at any one place to create a draught. There are also air-flues in the corridors and in the crush-room to carry off the products of combustion from the numerous gas-lights; and there are outlets into the roof from the side galleries. None but these simple expedients for ventilation are adopted, experience having, I think, shown that most elaborate systems of ventilation are liable to failures, more or less complete, in proportion to their greater or less elaboration. A copious supply of water is of course one of the first essentials in a theatre, as a precaution against fire, for it is clear that, if a fire is to be resisted successfully, it must be so within the first quarter of an hour, as after that time the body of flame would be so vast as to defy all control. The precautions sometimes provided of iron curtains, and the like, are of questionable value, as when most wanted they are seldom available or in order, and the only valid precaution appears to be to provide plenty of cocks, with a high-pressure water supply, in all parts of the building. At Covent-garden there are twenty-five of these cocks, supplied from cisterns in the roof capable of containing 12,000 gallons. The main cistern is placed over the stage stair, in the north-west corner, towards Hart-street, and in order to secure a constant supply in case of fire, the cistern is divided into two unequal parts, the smaller of which supplies the closets, sinks, and taps of the house, while the larger is entirely reserved for the supply of the fire-cocks, at high-pressure. The supply to the cistern is so arranged that not a drop of water can find its way into the smaller compartment until the larger is full to overflowing. As long, therefore, as there is any water in the closets, &c. it is certain that the fire-cocks are charged; and if by any chance the supply should run short, the inconveniences would be at once felt and remedied.

It may possibly be remembered that when the theatre was opened to the public on the 15th May 1858, the tympanum of the portico was not built, and the removal of the scaffold was

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not completed until the afternoon of the opening day. It had been intended not to have attempted the erection of the portico until the next year, but considering the inconvenience and interruption to the business of the theatre that might be expected by a renewal of the works at the principal entrance, Messrs. Lucas were asked as late as March 1858, whether they would then undertake to erect the portico—the columns of which are 36 feet high and 38 inches diameter—before the 15th May, leaving the tympanum only to be added afterwards. This they consented to do, and on the 27th March the order was given to proceed. On the 22nd of April the last capital was set, and the last stone of the architrave was fixed complete on the 8th of May, just one week before the opening of the theatre, although the ground at the theatre was now so crowded that every stone had to be worked at the wharf in Lambeth.

After the portico was completed iron beams were fixed over the space between the front wall and the colonnade, a beam being placed across each column. At the close of the season a platform of scaffolding was formed upon the iron beams, and the tympanum carried up entirely from the same, the space thus formed being converted into a practising room, 74 feet by 14 feet, over the portico, and entered from the back of the theatre gallery.

In fitting up the interior of the auditory it was resolved to allow to each spectator a more liberal share of room than had formerly been the case, and the consequence of course is that the actual number of persons accommodated suffers a corresponding diminution. When the theatre is used for the opera, the number of spectators comfortably seated amounts to 2300; but when otherwise fitted, 3000 or more visitors can be easily accommodated.

The paper was illustrated by a great number of drawings, diagrams, and photographs. The following table gives the relative proportions of some English and Continental theatres:—

	Width of proscenium.	Boxes in each tier.	Tiers of boxes.	Width between boxes.	Length, curtain to centre box.	Height, pit to ceiling.
	ft. in.			feet.	ft. in.	ft. in.
San Carlos, Naples ...	53 0	29	6	70	70 0	70 0
La Scala, Milan	43 0	41	5	66	88 6	69 0
Theatre at Bologna ...	51 0	25	5	57	78 0	63 6
Theatre at Turin	42 6	29	6	52	61 0	53 6
Her Majesty's Theatre ...	37 0	43	6	59	88 0	51 0
New Covent-garden ...	50 0	36	4	63	81 0	65 6

ANGULAR TROUGHS OR PIPES, AND ANGULAR BOTTOMS TO DRAINS.*

By C. H. G. Thost.

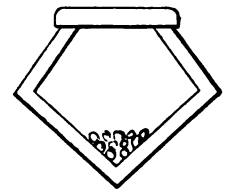
Dissatisfied with the means of conveying the lead-ore from the mines to the stamping mills at Tyndrum Mines, I was led to devote my attention to the possibility of taking advantage of the moving power of water in close drains or pipes.

For this purpose a square pipe or trough was laid down from the entrance of the mine to the low grounds, a distance of 1200 feet, and having an inclination varying from 13 to 20 degrees. But though the water rushed through this pipe with great velocity, it failed to carry the fragments of ore along with it; these choked up the very mouth of the pipe. Having therefore failed in carrying out the idea in the square tube, numerous experiments were tried as to whether altering the form of the pipe would enable the object to be effected. The results showed such a superiority of the angular over the flat, curved, or other forms of bottom, that it was determined to try the experiment once more on the large scale with a tube of that form. The square box or pipe which had been laid down from the entrance of the mine to the low grounds was therefore as a preliminary turned on its edge, so that its bottom, instead of being flat, represented an angular channel, each side of which was inclined at an angle of 45 degrees.

The lead ore, broken to the size of ordinary road metal, was fed by a hopper into the top of the tube; a moderate stream of water was admitted along with it, and the whole ore was passed through the tube with an astonishing rapidity, and was delivered at the bottom, no choking taking place at all. Further experiments were made to ascertain the best angle at which the two sides of the base should meet, and it was found that a right angle answered all the purposes better than any other. With such an angle a smaller quantity of water was required to move the pieces of ore in the tubes; and the smallest gravel also, or even the powder of the ore, could be most effectually sent down.

The whole arrangements and general working of the mine were therefore modified so as to permit of this new mode of moving the ore being adopted; and now, not only is the whole ore conveyed by this means, but also all the residuary masses of quartz and other minerals which are cleaned from the lead ores previous to their transmission, are all got rid of by the same means, and deposited with little labour or expense in any desired locality.

To permit of the great wooden trough or pipe which conveys the ore from the mines to the low grounds being easily inspected and repaired, it is now made of the figure represented by the accompanying woodcut, being in fact just the square box set on one of its angles, and having the upper angle sawn off. A moveable cover is fixed securely down by means of cross bands of hoop-iron, the ends of these bands being secured by means of iron pins, so that any part of the trough can be readily opened for repairs. The lower angle of the pipe is lined with hoop-iron, as without this protection it was found that the angular fragments rapidly wore away the wooden sides. When thus protected the friction against the sides seems to be much less than might have been anticipated.



Let us now consider the conditions under which the action of the water in moving these masses of ore down such a tube takes place. The resisting power or stability of a block of ore is diminished by the inclination of the tube and by the buoying-up power of the water; and the effectiveness of the action of the stream against the block is secured by the latter not being able to assume any firm position in the channel where it could escape that action. The inclined direction of the flat parts of the tube can offer no such hold to the block as it could obtain in the case of a flat-bottomed channel. In the experiments with the flat-bottomed tube, when the fragment fell on its flat side, there it stuck; but in the angular tube, from only touching the sides by one or more corners, it was in a position to be easily acted upon by the current.

The cost of this mode of conveyance may now be stated. The original cost of the angular wooden trough at Tyndrum, 1200 ft. long, including all fittings, and lining the lower angle with hoop-iron, was £70. This trough has been many years in use, and is still quite good; but the annual repairs, chiefly consisting of renewal of the hoop-iron lining, amount to £11 or thereabout. This trough conveys yearly to the low grounds from 1100 to 1200 tons of ore. The ore is supplied to the pipe through the mouth of a hopper; the person attending to this is able, for the wages of one shilling, to get 40 tons down. This mode of conveyance is therefore the very cheapest yet tried, and as the same means are now applied to the removal of all the debris from the mines, the saving of expense is very considerable. The like system is now employed in the various processes of dressing and washing the ore, the troughs in these cases being open, and many of them are nearly level.

I wish to direct attention to the application of the angular form of bottom to ordinary drains and sewers. It is well known that the great object in giving a particular form to drains or sewers is to prevent the deposit and lodging of mud or sediment of any kind in them. Flat-bottomed drains were found to silt up so soon, that they have been generally abandoned; and as it was seen that circular pipes did not so easily become obstructed, some approach to the round form has been usually given, thereby incurring considerable expense. Now, though sediment of any kind is much less liable to collect in these curved-bottom drains, yet they are inferior in this respect to the drain with an angular bottom, as has been fully brought out during the numerous trials I had to make at Tyndrum before hitting on the angular form. And as I there found that even the finest powder of lead-ore (which is many times heavier than ordinary mud or sand) was removed from these angular pipes even when at the most moderate inclinations, I am inclined to believe that the general adoption of the angular bottom for all kinds of drains would be a great improvement. In this form of bottom, however small the

* Paper read at the Royal Scottish Society of Arts.

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flow of water may be, it always runs at that part where sediment can alone settle; and on the occurrence of any greater flow of water, either from heavy rains or occasional flushings, every particle of solid matter would be carried out of the drain.

The adoption, then, of the angular bottom would not only appear to form a more perfect sewer than those at present in use, but from the cheaper character of the bottom a considerable saving in the original outlay would thereby be effected. The bottom angle might be constructed with brick in good cement, or be lined with hard flat stones; but the important point to be attended to is to make the junction at the angle perfectly secure.

THE CENTRE MARKET HOUSE, WASHINGTON, U.S.

THE design for this structure, which has been adopted by the commissioners appointed to carry out the will of the corporation, will occupy and inclose nearly the whole of what is known as the Centre Market space, bounded by Pennsylvania-avenue, B, Seventh and Ninth streets, and forms a hollow square. The avenue front is 500 feet long and 80 feet wide, extending from the corner of the Avenue and Seventh-street and west to Ninth-street, with the exception of a large projection, together with a tower and covered porch for carriages, opposite to Eighth-street. The market or first story is 25 feet high, thus making a total height of the walls of this main building about 60 feet. The projection towards the Avenue opposite to Eighth-street is for the two iron staircases to the great hall, and for rooms and offices connected with it. The tower is 30 feet square, and upwards of 200 feet high, intended for a clock and an alarm bell.

The grand staircases are a prominent feature of this portion of the plan, being the principal, but not the only means of access to the second story, or great hall. There are also other spacious staircases at either end of this front edifice, thus giving the most excellent disposition of the hall above into separate apartments, with separate entrances, and also affording the most ample means of ingress and egress to the second story, as one great hall.

On the two south corners of the market space are buildings about 48 feet square, and of the same height as the great front portion of the building facing the Avenue. The second stories of these corner buildings are intended for restaurants, and the third stories for kitchens.

Connecting the front building which faces the Avenue with the corner building on B-street, above described, and also connecting these corner buildings with each other, are one-story buildings about 48 feet wide and 25 feet high, thus forming a complete inclosure of building, with two fronts of 500 feet in length each—one on Pennsylvania-avenue, and the other on B-street—and two fronts of 280 feet each, one on Seventh and the other on Ninth-street. The whole space thus inclosed by the outside walls, including the projection, will be $3\frac{6}{10}$ acres, and the space covered by actual buildings will be $2\frac{1}{8}$ acres. There will be two wide entrances on B-street for waggons, and two passages for egress, one on Seventh-street and one on Ninth-street. In the centre of the B-street front are several rooms for the officers connected with the market. There will be nine entrances to the market on B-street, and nine entrances on Seventh and Ninth-streets each. There will be but one entrance on the Pennsylvania-avenue front through the tower—this last entrance being intended not only for foot passengers, but for those from the covered porch.

An examination of the interior arrangements shows a well-matured system of drainage and sewerage, with an ample provision of water and water-closets, together with heat, light, and ventilation, giving all the convenience which such a building could be expected to afford.

The second story of the Pennsylvania-avenue front contains four halls, which are so arranged as to be converted into one grand room, with a total length of 400 feet, besides the most spacious accommodation for the mayor's court and the offices and rooms thereto attached. Mr. Haskins, of Washington, is the architect.

This great market house will rank among the largest in the world, and will compare favourably with any other, not only as regards its plan, arrangements, and details, but also as to its architecture. It is pure Italian in character, with the Mansard roof, now much in vogue in the United States as well as in many parts of Europe, and exhibits great simplicity of detail, with magnificent and commanding proportions.

ANCIENT DOMESTIC ARCHITECTURE.

(Continued from page 52.)

"We may now leave the country, and examine a town of the fourteenth century. It is a fact as yet but little known, that a town newly planned and laid out in this age was invariably of the most regular and monotonous arrangement, all the streets being at right angles and generally equidistant from each other. It is a great mistake to imagine that this method of arranging a town was first exemplified in such modern cities as Turin or Mannheim, or in the still more modern cities of the United States. Where a city grew up in remote antiquity near a river, as in the cases of London and Paris, the plan was always of a most confused kind. Towns of pure Roman origin are generally formed by two streets meeting at the right angles in the middle. But in these cases the spaces between the arms of the cross have been gradually filled up at haphazard, and of course, where a town was walled, the growth of population restrained within the limits of the fortification set at defiance any regularity of plan. But, we repeat, the more formal plan was adopted invariably in all new towns, or in all considerable additions made to ancient cities in the middle ages. Thus it will be remembered, that when the *enceinte* of Florence was enlarged by Arnolfo, according to the decree of the Republic in 1284, the new extension of the city towards the north-east was laid out with the most rigid symmetrical uniformity. The towns founded by Edward I. in his French provinces, such as Montpazier and Libourne and Montségur, which are still called Villes Anglaises, are the best known examples of the mediæval principles. A recent writer in the 'Annales Archéologiques,' M. Felix de Verneilh, has attempted without much success, to show that these bastides were not originally of English invention.

Had new Winchelsea ever been finished, or had it kept its commercial eminence, we should have had an example of these symmetrical towns at home. But this cinque port never recovered itself; and its desolate site gives us scarcely an idea of what its founder meant it to become. Its rectangular streets, however, may still be traced, and the vaulted undercrofts of many of its houses; and the splendid fragment of a stately church occupying one square of the ground plan. All else has perished, except one or two gateways, and some remains of a Dominican chapel. The town of Kingston-upon-Hull, also founded by Edward I., retains to some extent its symmetrical plan, and its church, but few other indications of antiquity.

One curious result of the policy of Edward I. in founding these new towns—which may be recognised on a map of France by the perpetual recurrence of the names Ville-neuve and Ville-franche—was, that it has preserved almost intact from that day to this, except by the natural course of decay, some of the still more ancient towns which were then deserted in consequence of the greater privileges conferred upon their new rivals. Such a town is that of St. Emilion, now sacred to antiquaries for its old streets and its curious rock-hewn church, and to claret drinkers for its wine; but which was utterly ruined, commercially and politically, by the foundation of the Libourne already mentioned, a town named after Roger de Leybourn, of Leybourn in Yorkshire, the representative of the English sovereign.

The architectural beauties of a fourteenth-century town of the first-class were very great. The churches, the town halls, the halls of the various guilds and hospitals, were often, as we know by many surviving examples both at home and abroad, of great magnificence. The Hôtel de Ville of Ypres, and that of Louvain, will occur to every one; and those who have visited Italy know that its ancient cities are full of noble remains of secular Gothic architecture. It is from public buildings of this class that the happiest inspirations have been drawn by our foremost modern architects for the adaptation of the Pointed style to the similar wants of our own age.

Of the ordinary dwelling-houses however of this period it is less easy to speak positively, so few of them, comparatively speaking, having come down to us without alteration or mutilation. It may be shown however that the house of a wealthy burgher included a great hall as well as a parlour. The houses generally seem to have risen to three stories in the fourteenth century. The servants slept in the hall: and the parlour or solar was used by the master and his family. M. Viollet le Duc has given a most interesting chapter on the Vie Privée de la Haute Bourgeoisie; from which we gather that it did not differ materially, or in kind, from that of the higher ranks. The history of the dwellings and private life of the lowest class of all has yet to be written, if there are any materials to be found. In addition to dwelling-houses, warehouses and stores now begin to be mentioned in wills and other documents. How much architectural character could be given to these piles of building in the Gothic style is familiar to all who have seen the imposing ranges of warehouses in the ancient city of Nuremberg.

Before quitting the fourteenth century, we may again refer to M. Viollet le Duc's representation of a French room of this period. Here he has very ingeniously translated all the details of his earlier picture into the later style. The chimneypiece has lost its archaism, and the wood-carving has become more graceful and elaborate. Here, too, we have a peep into another room—the garderobe, shown *en suite*, with curtains between the two, but no door. The bed has become more like a four-poster, which might be taken for a modern one, were it not for the

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characteristic carving of its legs and head. The windows are furnished with shutters above and below the transome. A buffet on one side groans under plate and ornaments. The high-backed benches have become more ornate, and are furnished with canopies like the sedilia of a church. In this plate, for the first time, two light moveable *chairs* make their appearance. We should be inclined to think this premature. A stool was for many centuries the only moveable seat; and the introduction of such light and elegant chairs as M. Viollet le Duc has sketched must surely have been later. The floor appears to be tiled, with rich carpets spread in various parts. The *ensemble* of the room is quite as beautiful and picturesque as it is 'comfortable.'

We now turn to the fifteenth century, in the domestic architecture of which we shall find, as might be expected, a very marked increase of refinement, and a considerable approximation to the peculiar requirements of modern habits. It became less and less necessary, for instance, to protect the ordinary dwelling-houses of this age from the danger of an enemy's attack. The type of the mere stronghold, therefore, gradually died out, and that of the mansion took its place. The transition between the two, and the temporary blending of the distinctive features of each, may be observed in castles such as those at Kenilworth, Alnwick, or Warwick, which received from their successive inmates additions or alterations to suit them to the changing habits of the time. As feudalism declined, the necessity of keeping a band of retainers ceased, and the common hall was no longer the main feature of a great man's house. We have already seen in the preceding century that the importance of the hall began to wane when the lord and lady withdrew themselves from the common meal and dined in private. At last, with the disappearance of the armed followers vanished the necessity of providing a special room for their entertainment; and henceforward the hall, if retained at all, was nothing but a tradition. So, too, moats and portcullises and machicolations lost all their significance when no hostile attack was likely to happen. Accordingly, such castles as Hurstmonceaux in Sussex were from the first quite as much a domestic mansion as a stronghold, and Thornbury Castle and Cowdray House, both well known examples, merely retained a pretence of fortification as an ornamental feature. The remains of the fifteenth-century mansions afford an infallible key to the relative social states of the districts in which they were built. Thus the border country was not yet safe enough for the domestic element to prevail; and in Ireland every house was still strongly fortified. In more settled neighbourhoods the continuance or the abandonment of fortification seems to have been a matter of indifference or caprice..... Gatehouses were doubtless built, and turrets machicolated long after any serious idea of defence had been abandoned. Thus, to take the example of the old rectory house at Chesterton, close to Cambridge, who can suppose that that picturesque bartizan on one of the angle turrets was ever meant for anything but an ornament. The rest of the building, with its large windows, has no appearance even of having been supposed to be liable to attack.

Doubtless other social causes besides those mentioned above contributed to accelerate the disuse of the common dining-hall. Among them must be reckoned the growth of a shopkeeping middle class, which took the place of a considerable portion of the servants that had been hitherto employed in each household. It was not only the armed followers—the swashbucklers—who were no longer wanted. A great deal of the necessary work of providing the meals of the family was now done by independent tradesmen. It was no longer necessary for every man to keep his own tailor or brewer or baker. The lower classes, gradually but steadily escaping from a practical serfdom, had gained their independence and amassed comparative wealth, and devoted themselves to trade and industrial pursuits. Many a village began now to have its substantial shops, predominating over the still wretched hovels of the agricultural labourers. The dining-hall was, from these various causes, less used and less filled by night as well as by day; and before long it disappeared altogether.

Meanwhile, as refinement increased, the private apartments became more and more important. Separate bedrooms were now considered absolutely necessary; and the solar, or withdrawing-room, was no longer the mere private boudoir of the heads of the household. It was enlarged, and became the ordinary sitting-room of the family. It has been said that the cottages of the peasantry shared in this century the general improvement of the architectural art. We see, however, no evidence of this, and we greatly doubt it. Our own days have been almost the first to witness a movement for improving the dwellings of the lowest class; and in many a thriving modern manufacturing town, and many a well-managed estate, the labouring man has now a decent and befitting abode. But the majority of cottages, both urban and rural, are still scarcely fit for human habitation. One, or at the most two rooms, for a whole family, to the destruction of all decency and morality; very often no ventilation except by the door and chimney: such is the condition of too many cabins to this day in rural districts. Each hut, indeed, has its chimney and its glass windows—luxuries unknown to the mediæval cotter: and the furniture and utensils are more in number, and more convenient, in the poorest cabin than they seem to have been in earlier times, if one may judge from wills and inventories; but in other respects there is less difference than there ought to be in the dwellings of the poor between mediæval times and our own. And this is more especially true of the stone-producing districts, in which many a hovel formed of rude masonry may in fact be of great antiquity. The cheap brick, destructive as it has been to the picturesque of architecture, has been no small boon to the poorest class of householders, by providing a better substitute for their wooden or mud cottages at a small comparative expense. In spite of their liability to destruction by fire, it is really surprising how many timber or half-timber structures of the fifteenth century have been preserved to us, not only in country places, but in towns, and even in London itself. We believe that many of the Kent villages contain their ancient timber cottages under modern casings. The picturesque village of Chiddingstone in that county retains its timber cottages in their original state, and almost without the admixture of modern houses. The promising work on Ancient Domestic Architecture, by Messrs. Dollman and Jobbins, the title of which we have added to the head of this paper, is to contain, among its other details, exact drawings and details of one of the most perfect and best-preserved specimens of a fifteenth-century cottage of the better sort, taken from this village.

Of town mansions of the fifteenth century, Crosby Hall in London, St. Mary's Hall at Coventry, and that of the famous woolstapler, John Halle of Salisbury, are well-known examples. The great Fire of London destroyed almost every specimen of the houses of the smaller tradesmen: but what these were may be seen in the contemporary houses of the provincial towns of Tamworth, Coventry, and Weobley, and in many others. It would seem, from an examination of these, that open shops—in the present sense of the word—were still uncommon. Each house had its cellar, which was generally vaulted, half under ground, with its solar and bedroom above, and a store-room in the roof. It was in fairs or markets, and not at their own houses or shops, that the fifteenth-century traders exposed their goods for sale. Still there were shops in many places. Thus the Fabric Rolls of York Minster, lately published by the Surtees Society, tell us of certain persons being presented for opening their shops, *schoppas*, on Sundays, *infra clausum*, 'within the close' of York Minster. The Butcher-row at Shrewsbury is supposed to be the best specimen of mediæval shops remaining to us. It is evident that shops could not become common till the half subterranean undercroft was disused. The famous 'Rows' at Chester probably had their origin in some extensive rebuilding of the city after a fire. The stone cellars were uninjured, and were accordingly preserved; and the new shops were constructed over them by taking a passage out of the solar, on a higher level than the street. The disuse of the stone-groined undercroft, and the use of the ground story as a shop, effected a gradual revolution in town housebuilding. The solar and bedroom then came to occupy the first floor, and an additional story was gained in the whole height between the solar and the garret.

A very graphic description of a mediæval town is given by Lydgate. Not the least curious thing in this poem is the notice of the sewerage arrangements in his model city. He says—

'And every hous couerid was with leede,
And gargoyle and many hydous heede,
Withe spoutes thorugh, and pypes as they aughte,
From the stoon werke to the canell rought,
Voydynge fylthes lowe into the grounde,
Thorugh grates perced of yron perced rounde,
The stretes paued bothe in lengthe and brede,
In cheker wyse with stones whyte and rede.'

And again, speaking of the river which drained the town,

'By archis stronge, his cours for to reflecte,
Thorugh condyte pypis large and wyde withal
By certeyne meanes artificiall
That it made a full purgacion,
Of al odure and fylthes in the toun,
Wasshynge the stretes as they stode arowe,
And the gutters in the erthe lowe,
That in the city was no fylthe sene,
For the canell scoured was so clene,
And deuoyded into secrete wyse,
That no man myght espye nor deuyse,
By what engine the fylthes fer nor nere
Were borne awaye by cours of the ryvere.
So couertly euery thynge was couered,
Whereby the towne was utterly assured
From endengerynge of all corrupcion,
From wicked ayre and infexion.'

If the doctrine of the utilisation of sewage did not prevail in the fifteenth century, yet the men of that time seem to have understood the theory and practice of removing it from human habitations. It has long been admitted that the so-called subterranean passages which are sure to be found in every old monastery or castle, are really nothing but the drains. It is a subject very well worth investigation among archæological inquirers, why the system of draining described by Lydgate was either not carried out, or, if carried out, abandoned.

The oriel windows at the upper end to light the dais, which are so conspicuous a feature of the halls in our ancient colleges, were first developed during the fifteenth century. Before that time the windows all along the sides of the room were generally uniform. This bay window held its ground, even when the hall itself began to disappear. In some late examples the hall was divided into two floors, and the oriel ran through from the lower to the upper story. Hence it was an easy transition to introduce it into any conspicuous part of the house, running, as a general rule, through all the floors. Some fifteenth-century mansions,

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such as Thornbury Castle, Gloucestershire, may be almost said to be composed of bay windows, of every variety of plan. This vast area of fenestration is a specialty of the Pointed domestic style, which proves its peculiar fitness for our English climate. No sooner had it become possible, through the general introduction of glass and the entire absence of any need to keep the openings small as a defence from attack, to increase the size of the windows, than the domestic style of Pointed developed a method of fenestration of which it may fairly be said that it allowed the whole side of a room to be panelled with windows. In some cases this was almost literally true. Colston's house in Small-street, Bristol, is little else than a glass house set in a Perpendicular framework of timber. Hence it has been well observed that the Crystal Palace itself is little else than an expansion and translation into iron of the type of a late Perpendicular or Third Pointed panelled structure.

In further illustration of the use of the great hall for festive g therings, Mr. Parker, in his 'Account of Domestic Architecture in England from the Conquest to Henry VIII.,' gives a curious engraving from a manuscript of Quintus Curtius, of the fifteenth century. The drawing evidently represents the dress and manners of the time. The tables—which were always moveable, mere boards laid on tressels—are here removed. The king sits on his chair of state on the dais, with some ladies stiffly ranged on either side of him. A costly hanging forms a kind of canopy, and a rich buffet or sideboard covered with plate and cups and bowls, stands on the right hand. A number of guests are already arrived, and are standing or sitting in groups, while some servants are bearing refreshments; the jester is gesticulating in the middle of the floor, and the minstrels from their gallery at the other end of the hall are giving a blast of trumpets. It is worthy of remark that all the male guests represented in this most instructive picture have coverings on their heads: the women all wear a tall white cap, like a sugar-loaf, with a scarf hanging behind. The present custom of going bareheaded within doors has only become universal since draughts have been quite excluded by modern improvements in building. To resume. In this most curious illustration a carpet is laid down on a dais, and a mat before each bench. No such thing as a moveable chair is shown. It may be worth observing that the 'open seat' or bench of our churches is nothing else than the ordinary seat of a mediæval house. Almost every country alehouse retains to this day its 'pew' or bench, which is often furnished with a high back and canopy. It seems unreasonable that we should now retain in our churches a kind of seat which, from its cumbrous discomfort, we have discarded from our houses. If we followed the spirit of the mediæval church arrangements rather than the mere letter, there is no doubt that we should use chairs in the naves of our churches, as has been done with such good effect in Westminster Abbey and St. Paul's, on occasion of the special services. The floor of the hall in this engraving is paved with tiles. As we have before mentioned, it was not till this century that it was usual to pave the hall at all. We have no doubt that many churches also were unpaved, at least in their naves. It is on record that the ante-chapel of King's College, Cambridge, was not flagged till some time in the last century.

No greater improvement in social habits was introduced in the fifteenth century than the custom of multiplying the sleeping apartments. Many of the servants in a great hall may still have slept upon straw or loose bedding in the hall, but the number of separate chambers was increased indefinitely in this age, as may be seen in any remaining house of the time, such, for example, as Haddon Hall. In some mansions of this period, when the hall had quite disappeared, a dormitory was formed in the roof, open to the ridge, and often extending the whole length of the house. This, at any rate, was far better than the use of the hall as a sleeping-room. Perhaps the long galleries which are to be seen on the upper floors of houses of the next century, such as Bramshill in Hampshire, or Hever in Kent, were intended for at least occasional use as dormitories, when many guests and their servants might be in the house. To this day our old farmhouses in almost every part of England will show, upon examination, that the whole upper floor in the roof was originally one common sleeping-room. In most counties it is now divided by later partitions; but there are places where, to the entire destruction of morality, the old arrangement is virtually retained. It marks a period in refinement of manners when such a servant as a 'groom of the chambers' first makes his appearance in a household. The chambers were attended to by male servants at first. At present in a great house the name of this official is retained, but other duties have been found for him. He still, however, designates to each guest on arrival his proper bedchamber.

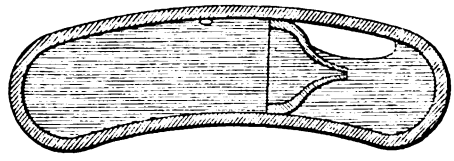
The staircase of a fifteenth-century house was a great improvement upon its predecessors. The old newel-winders were not indeed discarded altogether. but they were made broader and more convenient, and in many places they were superseded by wide straight internal stairs. Of this the ruins of the archiepiscopal palace at Mayfield afford an excellent example. Corresponding to the enlargement and improvement of the stairs was that of the corridors and passages. Sometimes in timber houses these were external, and continued along the whole length of each floor. The abbot's house at Wenlock is a beautiful example. Such a panelled arcade, glazed as a protection from the weather, would be an excellent feature in a modern house."

ON SEVERAL FORMS OF SPIRIT LEVELS.*

By Robert H. Bow, C.E.

There is a degree of delicacy in the action of spirit-levels that at once places them above all pendulum-like arrangements; and by employing chloroform instead of, as formerly, spirit, naptha or ether, that delicacy of action is greatly augmented. A further step in their improvement has been the application of a means of regulating the size of the bubble, by Prof. C. P. Smyth (Fig. 1).

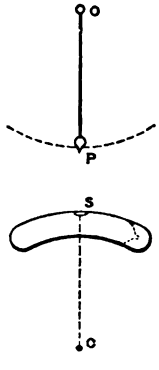
Fig. 1.



The bubble of the common level is liable to become too large in cold, and too small in warm weather; but by Prof. Smyth's invention, any desirable size of bubble can at any time be produced; and the very minute ones required in his instruments, and which it would be impossible to deal with in the common levels, are readily obtained, and without any danger of the tubes bursting in warm weather.

The common level is employed to point out the horizontal position of the instrument; the curved level, on the other hand, may be looked upon as more of the nature of an inverted pendulum; in it the centre of curvature. C (Fig. 2), may be taken as representing O, the point of suspension of the pendulum, and S the bubble, as representing P, the plumb-bob; the bubble S ever tends to place itself vertically over the point C. There is this important difference however, that when the two instruments are equally disturbed, the pendulum will continue its oscillations so long as to render it useless for our present purpose; whereas, in the case of the curved level, the small bubble comes almost immediately to rest.

Fig. 2.



If we had only to consider the mobility of the bubble as dependent upon the changing inclination of the tube, the problem of constructing an instrument capable of correct and minute reading, without the use of a fixed support, and in the most disadvantageous circumstances, would still be a possible achievement. But unfortunately, in the case of all levels that are intended to be simply held in the hand, or used on shipboard, there is one pervading source of error arising from the motion of the fluid, induced by the unavoidable horizontal swaying of the instrument. This horizontal movement affects more or less all levelling instruments, whether founded on the equilibrium of fluids or solids.

On land certain expedients may be resorted to to do away with this source of error; but at sea, where the matter is of such great importance, its complete elimination is, it is to be feared, a hopeless task. It may, however, be so far reduced as to render the observations valuable to the navigator, by modifications in the instrument, by skill in the observer, and by having the length of the vessel placed in the direction of observation.

These latter points rather belong to the use of levels in instruments for the angular measurement of altitudes. Let us return to the consideration of the question on *terra firma*.

When the object of the observation is only a rough approximation to the true horizontal line, the error arising from swaying need not be alarmingly great, even when supported by the hand alone. When, however, a more correct result is required, two methods of doing away with this cause of error offer themselves to our choice. First, a light stand may be used on which to rest the instrument; this may have either two or three legs. When there are only two, they should open in the direction of the observation; and since the instrument is assumed to be self-adjusting, no time is consumed in planting the stand, the only drawback being the less portable character of the whole apparatus. Second, the spirit-level may be inserted near the bottom of an elongated form of the instrument, so that, though it at top sway considerably, the effect of such motion on the level placed at the end resting on the ground will be so much reduced that it

* Paper read at the Royal Scottish Society of Arts.

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may be altogether neglected. This arrangement has the further advantage of the eye being always at the same height from the ground.

Fig. 3.

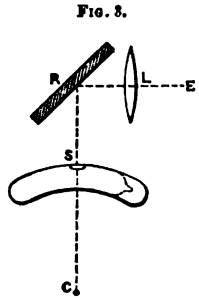
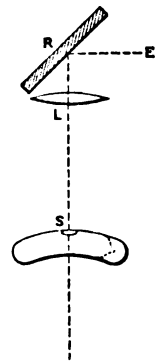


Fig. 4.



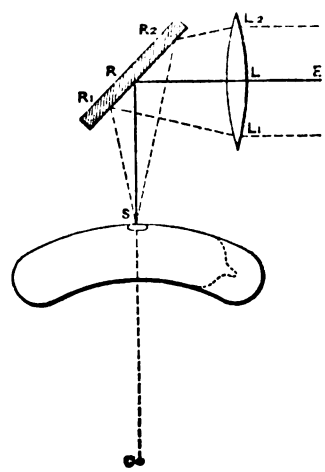
Prof. C. Piazzi Smyth's Spontaneous Horizon Point consists essentially of three parts—viz., a curved spirit-level S, a reflector R, and a lens L, as shown in Figs. 3, 4, &c.

In Figs. 3 and 5, the ray of light, or line passing up from the centre of curvature of the level C, through S, the centre of the bubble, and on to the reflector R, is necessarily a vertical line; and when the instrument is so held that the bubble is at the central point of the tube, the mirror R is at an angle of 45°, and the ray CR is consequently reflected in the horizontal direction RE, passing through the centre of the lens L, and entering the eye or telescope held at E.

In the first place, it is necessary that all the other rays, such as SR, SR' (Fig. 5), &c., proceeding from the bubble, should be so bent by the lens as to become parallel to the central ray RE; and it is evident that this will be effected by using a lens having a solar focus equal to the length of the course SRL. By such an arrangement, a bright and perfect image of the bubble will be seen as though away on the horizon; and if the reflector R be very narrow, the landscape will at the same time be seen on either side, and consequently the height of the horizon upon it indicated by the bubble.

But when the instrument is inclined so that the bubble of the level is no longer in a central position, and the mirror no longer at 45°, we must see that another requirement is fulfilled, in order that the rays entering the eye be truly horizontal. In Fig. 6, then, attending to those rays alone which pass from C through the centre of the bubble in its various positions, and which are of course always vertical, let the instrument be inclined to the extent of say 5°, so that the line CS'R' is now vertical; this ray will be reflected in the direction R'L', differing by 5° from the line RL, and by 10° from a horizontal line; now it is necessary

Fig. 5.



to bend it into the horizontal direction L'E'. It is evident that a lens having a focal length equal to the course CRL would only be capable of bending the ray R'L' into the direction of L'F parallel to LE or 5°; but as we have seen, the ray must be bent to the extent of 10°; therefore the focal length must be equal to only half the course CRL, and by Fig. 5 it was demonstrated to be equal to SRL; consequently SRL, the focal length, must be equal to CS, the radius of curvature of the level. The same result would be obtained for the disposition of the parts shown in Fig. 4.

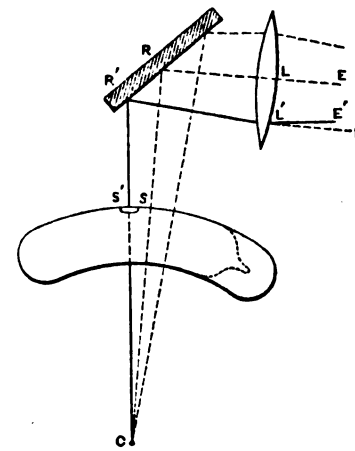
The action of the spontaneous horizon point may be illustrated in an inverted form, by substituting a pendulum for the level,—the lens having a focal length equal to the length of the pendulum, and placed optically at a distance from its lower extremity equal to the same length. Such a model may serve also to illustrate what was said of the inferiority of the pendulum as applied to levelling, from the continuance of its oscillations.

By a further improvement, constituting Prof. Smyth's "*spontaneous horizon point reinforced*," a level of greatly longer radius may be employed without entailing increased dimensions in the instrument. The advantage of a longer radius consists in a diminished angular disturbance from a swaying motion.

Such then is the "spontaneous horizon point." On observing with such an instrument, the little bubble appears to maintain a nearly steady position on the horizon, although the instrument be moved through several degrees in a vertical plane. The bubble constitutes the referring point, and no cross hairs are required in the telescope. The principle is a very beautiful one, and differs widely from that employed in the levels I am about to describe.

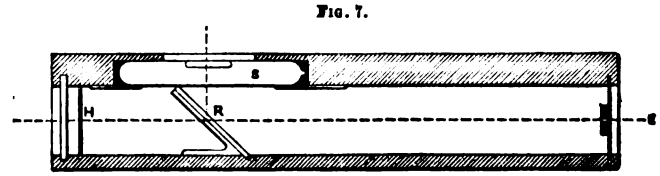
The principle upon which my instruments are planned con-

Fig. 6.



sists in such an arrangement that the observer may at one and the same instant note 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 is shown in Fig. 7: it differs but little in external appearance from the common pocket or workman's spirit-level, and may be put to the same uses, in addition to its particular duty of affording observations by being simply held in the hand while looking through it. It consists of a spirit-level S, sunk into the under surface of the top of the box, and immediately above the level there is a narrow slit, from 1 to 2 inches long, cut in the top of the box to permit the light from the sky passing down through the spirit-level; beneath the latter, and attached to the bottom, is a narrow piece of mirror R, inclined at an angle of about 45°, so as to reflect the image of the tube and its bubble

Fig. 7.



to the eyehole E. The small eyehole E, and the horizontal hair H, H, constitute the sights. G is a piece of plate glass to protect the hair. For judging of the steepness of gradients, a series or scale of horizontal hairs or wires may be stretched on a frame at H; a box deeper in proportion to its length being at the same time adopted.

The instrument constructed in this manner may vary much in power; if a common level tube of small diameter and a short box be used, the readings can only be taken very roughly, but it

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may nevertheless prove very serviceable in obtaining a general knowledge of the inclinations of the surface of a country. On the other hand, it may be possessed of considerable delicacy if the box be long, and the level tube be large and filled with chloroform. When however a still greater power of minute reading is required, a telescope must be combined with the level, and several different manners of carrying out the combination may be followed:—1. We may so construct the instrument that the position of the air-bubble of the superimposed level may be seen through the eye-piece, reflected from a strip of convex mirror placed between it and the cross hairs of the telescope. 2. We may reflect the rays from the bubble by means of a narrow piece of mirror R, placed inside the telescope, but near the object end, and from an image of the bubble near the cross hairs, by interposing a thin slice of strong convex lens. This is perhaps the most satisfactory form of the instrument with a telescope.* 3. The reflector may be external to the telescope, and near the object-glass, so as to throw in rays coming from the level, the rays being rendered parallel by an interposed lens; the spirit-level may be placed near the ground or otherwise. 4. We may have the telescope applied to one eye, while the box with the level and simple reflector is inspected by the other; the axes of the telescope and level being of course maintained perfectly parallel by suitable framing of the instrument.

The manner of using all these levels is thus:—The instrument must be slowly elevated or depressed, so that the bubble may be seen moving slowly, first in one direction and then in the reverse. The relative two positions of the cross hair, as seen against the staff or other object, must be carefully noticed, and the middle point taken as the correct reading. Practically it is found most convenient to watch one extremity of the bubble; but this may give rise to somewhat inaccurate results from its changing length from changes of temperature, unless the cross hair adjustment be corrected, or the standard length produced by employing a safety-level. For finer work it is an advantage to have the instruments attached to rods or stands of convenient length; by this a much more satisfactory observation may be taken. Again, when the support is such that the eye is always at the same height from the ground, and a point on the levelling-staff at that height be made the zero—the scales reading upwards and downwards from that point—then the observation will give the rise or fall at once, doing away with the necessity for any after deduction of one reading from another.

It is not proposed that these instruments should be used where very accurate work is demanded; but they may frequently prove valuable where the common instrument cannot well be used, or when rapidly obtained approximate results are required. The pocket instrument, Fig. 7, is the form most likely to meet with favour; it may be made very cheaply, and so as to stand rough usage; with it observations may even be made while on horseback or in a carriage; and the errors of judgment so often fallen into in regard to inclinations, or the height of the horizon in mountainous districts, corrected. It may therefore prove most valuable in the hands of a traveller desirous of becoming acquainted with the characteristics of the surface of a new country, or to the engineer in search of the best general route for a road, railway, or canal. Such an instrument would likewise be a valuable adjunct to the equipment of the worker with the common heavy tripod levelling apparatus, as it would save him from the frequent annoyance of finding, after adjusting his level, that he has gone on so far up or down hill that his telescope ranges altogether above or below the levelling-rod.

As to the originality of my inventions, much the same idea only differently dealt with, is embodied in the attached reflector to Gravatt's level, and also in an instrument introduced from France in the year 1851, and somewhat of the nature of a clinometer which Prof. Smyth placed in my hands. I have also learned that many years ago a similar method of observing the spirit-level was combined with a sextant for taking altitudes at sea.

On describing to me these older instruments, my friends kindly endeavoured to draw distinctions between them and my own. I confess, however, I have been more amused with their ingenuity than satisfied with their success. Indeed all I can expect to be credited with is, having been the means of resuscitating an old idea, and possibly with having brought it out in a form like Fig. 7, so simple and satisfactory as may lead to its introduction into general use.

* It is well to have two thin black plates of metal, of nearly the height of the tube, placed up against the strips of mirror and lens, and extending from one to the other.

INSTITUTION OF CIVIL ENGINEERS.

GEORGE P. BIDDER, Esq., President, in the chair.

Jan. 24.—The paper read was "*Description of the works and mode of execution adopted in the Construction and Enlargement of the Lindal Tunnel, on the Furness Railway.*" By F. C. STILEMAN, M. Inst. C.E.

It was stated that the Furness Railway, of which Messrs. McClean and Stileman were the engineers, had been principally projected for the conveyance of minerals. It was originally intended to have been a double line, and indeed the works were partially carried out with that view, but the monetary crisis of 1847 caused them to be suspended for a time. When resumed it was determined to make only a single line, which was completed and opened in June 1851. The facilities afforded by this railway led to a great development of the mineral traffic of the district. Subsequently an act of parliament was obtained for the formation of the Ulverstone and Lancaster Railway, thus completing the chain of coast railways between Lancaster and Whitehaven, and so onwards to Carlisle. It then became evident that a single line would be insufficient to accommodate the traffic. Consequently, in August 1854, it was decided to widen the line, and to enlarge, or open cut, the Lindal tunnel. The latter alternative was entertained in case it should be considered necessary to resort to that plan, in order to insure the regular passage of the trains during the progress of the works. But as it was found that the cost would be doubled, it was determined to enlarge the tunnel; the tender of Mr. W. Tredwell being accepted for that purpose.

The original tunnel was 563 yards in length, of which 176 yards were in solid rock, and 387 yards in loose material lined with sandstone rubble masonry. The contract price for the portion in solid rock was £6 per lineal yard, giving about 6*s.* 2*d.* per cubic yard, and for the part that was lined £15 10*s.* per lineal yard. The length of the enlarged tunnel was reduced to 460 lineal yards, of which 123 yards were in solid limestone rock, and 337 yards in loose material, lined with fitted limestone rubble, 2 feet to 3 feet in thickness, set in Aberthaw lime mortar; the stone being obtained from the adjacent cuttings. The additional cost of that part of the tunnel which was in rock amounted to £21 4*s.* per lineal yard, and of the portion which was lined to £38 per lineal yard.

The tunnel was increased in width equally on each side of the existing single-line tunnel, the level of the rails remaining the same. The works of enlargement were commenced in June 1855, at No. 3 old shaft. This was widened, and divided down the centre, so that it could be worked as two separate shafts,—one in connection with each side of the old tunnel. Top headings were driven for short distances, at the proper levels above the existing tunnel, when the material was found to consist of dry hard clay and gravel. It was observed however that the ground had become set and broken up from previous mining operations, to a much greater extent than could have been anticipated. The crown was kept sufficiently high to allow of the ground being excavated without interfering with the original tunnel. The cills for the support of the bars were placed 3 feet above the crown of the small tunnel, and rested upon it and the material forming the sides. A portion of the masonry between the cills was then removed, and the excavation for the side walls was proceeded with. The working by shafts being afterwards dispensed with, it was necessary, in order to obtain another "face" to work at, to break through the original tunnel. A man-hole, sufficiently large to admit a miner, was made through the soffit of the arch, and this was carried up until the heading was reached; the ordinary method of tunelling being then adopted. The cills were supported by two upright props passed through the haunches of the old tunnel, and by raking struts or stays. After the excavation had been completed to the level of the cill, and the materials had been removed, the arch and side walls were taken down, and the excavation at the sides proceeded with. Small cills were placed about half-way down the side walls, to carry the props supporting the ends of the first cill, and these again were propped from below, as the material was removed. A back cill to assist in carrying the crown bars, and a framing, called by the miners a "horse-head," to relieve the pressure on the cills, were also frequently used.

Four years having elapsed between the completion of the small tunnel and the commencement of the works for enlarging it, it was thought that in this time the ground would have become thoroughly consolidated. But the displacement of the roof had been so great, that water seemed to have been impounded in large cavities, one of which was met with near shaft No. 4. In one heading the materials, consisting of clay, gravel, and large stones, being very wet, soon acquired the consistency of mud, and oozed through the timbers, which were displaced, and filled up the heading. After a large quantity of mud had been removed, this was stopped; but whilst extending the heading, a continuous dropping was heard in advance of the work, giving unmistakeable signs of the proximity of the cavity. On widening out the heading, a large hole was discovered, the top of which was 70 feet above the rails, and about 28 feet below the natural surface of the ground. The mouth of this hole was timbered, and the space filled up, when the work was proceeded with, extra precautions being taken to avoid casualties. At a distance of about 38 feet from shaft No. 4, a vein of fine, clean, washed gravel, which extended from the heading towards the old shaft, was cut across its full extent. From the first this showed symptoms of running, and

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notwithstanding every care and exertion the length came in, causing a cessation of the traffic. The mineral and goods trains were resumed within six days of the fall; but it was thought expedient not to allow the passenger trains to run until the work was in a more advanced state. On examination it appeared that the bed of gravel ran out to and round the shaft, forming a large hole. The loose material with which the shaft had been filled up was thus set free, and dropping a distance of from 20 to 30 feet, nearly over the heading, brought down the work.

Before the works of enlargement were commenced, the contractor suggested that another single or twin tunnel, parallel with the existing one, could be constructed with less risk; and he offered to complete it for the same sum, notwithstanding the additional excavation necessary in the approaches. This proposition had not been favourably entertained, because there was no precedent for such a work, and because it was known that there were many and grave disadvantages in working a single-line tunnel. From its limited area, and owing in this case to its being on a gradient of 1 in 100, the atmosphere after the passing of heavy trains became so charged with steam and sulphurous vapour, that the platelayers could not work for any length of time continuously, and hence there was a difficulty in properly lifting and packing the permanent way. Again, the condensation of the steam upon the rails practically increased the expense of working.

From the commencement of the works in June 1855, to their completion in November 1856, nearly 7500 passenger trains conveying 112,000 passengers, and 2100 goods trains carrying 205,000 tons of minerals, &c. exclusive of light engines, had passed through the tunnel, without the slightest casualty to either description of train, or accident of the most trivial character to any individual. A special code of rules was arranged for working the traffic, and for watching and signalling every train. The stations at each end of the tunnel were in telegraphic communication, and there were semaphore signals at each entrance, connected by an endless wire. The wire was fastened to wheels at various points, having cranks outside the trough in which it was inclosed. A signal man, whose duty it was to remain in the tunnel, could, by means of a portable lever, lower both semaphore signals simultaneously. As a precautionary measure, the signal-man sounded a large gong on being informed by the telegraph that a train was approaching; and it was not until he had satisfied himself that no impediment existed to the passage of the train that he lowered the signals, and thus sanctioned the engine drivers to proceed.

Jan. 31.—The paper read was "*Upon the Means of Communication in the Empire of Brazil—chiefly in reference to the works of the Mangaratiba Serra Road, and to those of the Mauá, the first Brazilian Railway.*" By E. B. Webb, M. Inst. C.E.

It was stated that until a recent period no roads, in the English acceptation of the word, existed in Brazil. Yet its area was equal to twenty-three times that of the United Kingdom, and it had a coast line of about 3000 miles in extent. The sea-ports were frequently far distant from each other, and the communication between them was by sea. Inland, bridle paths were to within these last few years sufficient for the necessities of the inhabitants. These were occasionally improved by some wealthy proprietors, by the avoidance of a terrific ascent by the erection of a wooden bridge, and even by the building of a stone culvert. The increase of the population, and the development of commerce, led to augmented traffic; and as the troops of laden mules grew more numerous the yielding paths became more unserviceable. The provincial governments then took the matter in hand, taxing the troops of mules, and repairing the paths by contract. But being unpaved, and for the most part extending over a clayey surface, they were still at certain seasons impassable.

The province of Rio de Janeiro was stated to consist of two distinct regions. A small portion along the coast was but little raised above the sea-level, whilst the greater part was at an elevation averaging 2300 feet. The sea-face of this elevated land had however a much greater altitude. It was precipitous and rugged, presenting granitic peaks from 5000 to 7000 feet in height. This was called the "Serra do mar." A few of the descents through the gorges of this serra were paved at the cost of the province; the gradients varying from 1 in 6 to 1 in 9.

The first attempt at real road-making was the formation of a carriage road up the face of the serra to Petropolis, a small town at the head of the gorges leading towards the Bay of Rio de Janeiro. This road was not well laid out, nor were the works upon it considerable. It had an average gradient of 1 in 16, and had only recently been macadamized. Its summit level was about 2800 feet above the sea. It was stated to have cost £40,000 per mile, although there were no disbursements for land, legal or parliamentary expenses.

Over the sandy plain lying between the head of the Bay of Rio and the foot of the serra, the Mauá Railway had been constructed. This line presented no difficulty, excepting where a deep unhealthy swamp, from one to two miles in breadth, had to be crossed. The mode in which the ordinary excavations were carried on was not at all satisfactory, although an improvement took place when English barrows and shovels, and small trucks and rails, were introduced. Slave labour alone could be depended upon; the native poor Brazilian not being inclined to work hard. The wages of the slaves were about 1*s.* 4*d.*, and the cost of their food about 7*d.* per diem. In the year 1857, after a lapse of four years from the time alluded to, the price of labour and food had doubled. The cost of skilled labour was generally about double that of the ordinary description. With one exception all the bridges were of timber, with the certainty of a not very distant renewal. There was great difficulty in obtaining sound and durable timber, owing to its being almost impossible to collect in any single district a supply of one description, and also to the expense of transport to the place where it was required. An examination of a timber pier, which had been constructed for the southern terminus of this railway in the Bay of Rio, showed that not one pile, and very few pieces of the superstructure, had remained sound after being in place about four years and a half. All the wooden bridges had suffered in a like manner, and they had been replaced by works of either iron or brick. The rails used were double-headed, weighing 65 lb. per yard, seated upon Greaves' pot sleepers, laid on clear quartz ballast. The guage was 5 ft. 6 in. The rails did not appear to oxidise more than was customary in similar positions in England, nor had the cast-iron of the sleepers deteriorated. It was a single line 11 miles in length, and the cost of the works, with the rolling stock, might have amounted to £15,500 per mile. The traffic showed a continuous increase; but the company had failed to obtain that which promised to be a great source of profit, a concession for its extension northward above the serra from Petropolis. Neither had it enjoyed, like other Brazilian railways, a government guarantee.

Soon after the opening of the Mauá Railway, which was completed by the author, he was appointed engineer to the Mangaratiba Serra Road. The route of this road was through a gorge 100 miles to the west of Rio, descending to the port of Mangaratiba; on the summit it passed in a northerly direction to the great river Parahiba, at a distance of 55 miles from the coast. Over the original track about 22,000 tons of coffee descended to the port, and about 10,000 tons of general merchandise were conveyed up the mountains. The work was commenced in May 1855, by a body of Chinese, who proved utterly useless as labourers. But as of late years many thousands of Portuguese working men had emigrated to Rio, the works of the road were supplied with them. At one time there were as many as 68 petty contractors, each employing from 15 to 60 of his countrymen, so that in a few months upwards of 2000 men were at work. At first they refused to use the barrow and the shovel. The hoe, their only tool, was not however so objectionable along the steep sides of the Mangaratiba mountains as it was on the plains of Mauá. For a great portion of its length the road was cut out of the solid rock, chiefly gneiss or mica-schist. Immense rounded masses of pure granite were met with on the serra, and occasionally on the plains. Trap dykes were frequent in the ravines, and, dispersed throughout the cuttings, decaying masses of basalt and amygdaloid. The cuttings stood safely at ½ to 1, in most cases. The slopes of the embankments remained firm at 1 to 1. A thick-leaved grass of rapid growth protected the slope from the destructive action of heavy rains. The macadamized surface was 23 feet wide. A flagged drain, 3 feet in width, ran on the mountain side, and on the outer side a similar drain of 18 inches. The surface consisted of a pavement 9 inches deep, covered with a layer of granite metal 7 inches in thickness. A dry stone parapet, 3 feet high by 2 ft. 2 in. thick, ran throughout the whole length of the road. With the exception of one arched bridge and some storehouses, none of the masonry contained lime. All the walling, the parapets, and the culverts were built dry. The abundance of stone, and the great cost of lime in its purchase and carriage, led to its rejection. The masonry proved more satisfactory than almost any other branch of work. The Portuguese masons would make a good dry wall out of inferior materials, and with considerable celerity. The same could not however be said of stone work in mortar. If left to themselves, they spent as much time in filling the outer interstices as in building the wall itself.

On the Mangaratiba Road there was only one work worthy of note in dressed masonry, and this was notable only on account of its cost. Although the Portuguese dressed stone very fairly, their work, as compared with English stone-cutters, proved in this instance four times more costly. In a locality far removed from the shore, and at first difficult of access, a bridge with a chord of 52 feet, and a versed sine of 9 feet, occupied nineteen months of incessant labour. The coal, steel, iron and lime, with the supplies of food, were carried to the spot, during many months, on the backs of mules. Timber had been shown to be unadvisable in Brazilian bridge building;—at all events in Central and Southern Brazil. The enormous cost of this cut stone bridge, amounting at least to £24,000, notwithstanding the most unwearied exertions to diminish expense, proved that stone was not economical. Without doubt iron was the best material for bridges in similar situations.

The works of the Mangaratiba Road had cost about £12,000 per mile. The serra portions presented great difficulties. There was no road in England with an equal amount of excavation and masonry in an equal length. The practical result was, that animal power could not be used in the general traffic of Brazil upon macadamized roads with the same advantage which many other countries had derived from it. Locomotive lines, the author thought, were too expensive for general use; and he considered that Brazil ought not, for several years to come, to attempt

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more than one locomotive line for each sea-board province, with the exception of Rio de Janeiro. The author had recommended the employment of tramways, and had drawn up a report on the subject, which was embodied in the message from the president of Rio de Janeiro to the assembly last year.

Allusion was then made to the railways now in progress or in contemplation, which were said to be destined to work a commercial and social revolution in Brazil. But notwithstanding the stability and prosperity of that country, its public works and its agricultural operations were yearly becoming more and more embarassed, on account of the scarcity of labour. Hitherto the supply of labour and the means of colonisation had been considered separately. The author had suggested, in a document he had the honour lately of placing in the hands of the Emperor, a means by which public works might be made the instruments of populating the districts in which they were undertaken. This system, it was believed, would be adopted to a considerable extent on the San Paulo Railway.

In conclusion, the author referred to the important question of guarantees. Two distinct methods of guarantee were in operation. The shares of the Don Pedro Segundo Railway appeared only in the Brazilian market. Upon a stated capital an interest of 7 per cent. was guaranteed conjointly by the general and provincial governments. Only a small portion of this capital had been paid up, and one third of the whole had been raised by loan in London, in the name of the general government, at 4½ per cent. The difference in the two rates was to form a sinking fund, to replace the sum borrowed. The other method, that of guaranteeing foreign shareholders, as in the case of the two English companies managed by boards in London, did not offer much encouragement, for the shares of each company were at a discount. It might have been expected that investments in such undertakings, with a guarantee of 7 per cent., would have been largely sought after. It was felt that perhaps it would be more advantageous in future for the Brazilians to raise all railway money on loan. It might fairly be hoped, that ultimately Brazil, upon a calculation of the preponderance of good and evil, would not have to regret the epoch when English capital, energy, and engineering skill assisted her in utilising her own internal wealth.

Feb. 7.—The paper read was "*Description of the Works on the Netherton Tunnel Branch of the Birmingham Canal.* By JAMES R. WALKER, M. Inst. C.E.

It was stated that the Birmingham Canal Company now possessed 157 miles of canal, the ramifications of which reached nearly every colliery and iron-work in the district. Although it had now to compete with several railways, the traffic upon the canal continued to increase. Thus, in 1832 the coal conveyed was 1,492,000 tons, whilst in 1854 it amounted to 3,100,000 tons. The boats navigating the canal carried about 33 tons each.

The natural features of the country offered considerable difficulties to the construction of canals. A line of hills extended through Rowley Regis, Dudley, and Sedgley, portions of which rose to a height of 400 feet above the Wolverhampton level. Through these hills a passage could only be made by tunnelling. The old Dudley tunnel afforded this accommodation for a long period; but its small size and the increase in the traffic conduced to render it insufficient. It was 3200 yards in length, and in the portions lined with brickwork was about 8 feet wide, and 6 feet high above the water level. There was no tow-path, and the boats were propelled through it by men lying on their backs, and pushing with their feet against the sides and roof of the tunnel. This process was termed "legging." The time occupied in the operation was usually three hours and a half. As there was not room for two boats to pass, a certain number could only be admitted at each end alternately. Hence the delay at the entrances used to be very great, as many as 100 boats being frequently detained for several hours, and in some cases even for days. Notwithstanding these and other inconveniences, this tunnel was for many years the only means of communication between the Birmingham and Dudley canals. In 1854, upwards of 39,000 boats carrying 438,000 tons passed through it.

At length the complaints became so urgent, that the construction of a new canal and tunnel on the Birmingham level, from Netherton to Dudley Port, was determined upon. It was shown that the distance between Netherton and Birmingham might be reduced 4 miles, the ascent and descent of three locks be avoided, and by the increased size of the proposed tunnel the passage of boats be easy and expeditious. In 1854, Mr. Walker (Past President Inst. C.E.) was consulted, and in the following year an act of parliament was obtained authorising the construction of the works. The drawings and specifications having been prepared by Messrs. Walker, Burges, and Cooper, the contract was let to Mr. George Meakin, and the author was appointed the resident engineer.

The length of the new canal was 2¼ miles. It comprised ¼ mile of embankment, ¼ mile of open cutting, and 1¾ mile of tunnel. There were three embankments containing 106,000 cubic yards. They were generally 54 feet wide at the water level; but part of one, where a subsidence was anticipated, which had since occurred, was made 66 feet wide. The slopes had an inclination of 2 to 1. There were four cuttings, the earth removed from which amounted to 136,000 cubic yards. Two were 46 feet and two 40 feet wide at the water level, the slopes being 1½ to 1. The materials excavated were principally clay and marl. The width of the waterway was 30 feet, except in one cutting where it was 24 feet, and there was a tow-path on each side. The bottom and sides of the canal were lined with clay puddle, spread in courses, and twice cut and well trodden. Broken cinders were laid on the bottom, to protect the puddle from injury by boat-hooks, &c. The tow-path walls, which were built of brickwork, rested on these cinders, and fine ashes were introduced between the walls and the puddle at the sides. Iron guards were placed on the walls, and on these the coping bricks, rounded on the edge, were bedded and jointed in mortar. In order to avoid settlement, as far as possible the walls were built in long lengths and not more than 18 inches in height at one time. To prevent the walls being forced out, the water was where practical gradually admitted into the canal, as the puddle at the sides was carried up. In other cases timber struts were placed from wall to wall, which were not removed until after the admission of the water. These precautions were necessary while the walls and puddle were "green." The water had since been drawn out of several parts of the canal, without the slightest movement of the walls taking place.

For the accommodation of the collieries and iron-works situated near to the canal, seven basins or docks were made, varying in size from 300 feet by 33 feet to 75 feet by 24 feet. Their construction was similar to the rest of the canal, except that timber wharfing was substituted for the iron guards and coping. The walls of two of those basins were built with cinders in lieu of bricks, procured from the blast furnaces in the vicinity. They made a kind of rubble work, in courses 2 feet high, large pieces being used as binders. This material formed a substantial and durable wall at about half the price of brickwork. It was used for the foundations of many of the bridges up to the level of the ground, and several retaining and fence walls were built with it. Tow-path bridges were erected over the entrances to three of these basins. The superstructure consisted of two cast-iron girders, with covering plates of cast-iron, and brick parapets.

Four bridges, all of similar construction, were built to carry roads over the canal. The piers and abutments were of brickwork, with stone imposts and copings. The superstructure consisted of cast-iron girders, with roadway plates of the same metal, and brick parapets. Six bridges were erected at the junctions, to carry the tow-path across the canal. They were the same in construction as the others, except that the girders formed also the parapets.

At Tividale, near the north end of the tunnel, the Wolverhampton level canal was carried over the new canal, on a brick aqueduct of three arches. At each end of the aqueduct a cill and grooves were placed, to receive stop-planks, whenever it was required to draw the water out of the canal. The cill was of elm, and the grooves of cast-iron, built in and bolted to the tow-path walls. The bottom of the canal was protected by an apron of bricks laid on end in cement. Near Dudley Port the canal was carried over an occupation road on a brick aqueduct. Under the Wolverhampton level aqueduct there were two stop locks, with gates, cills, and grooves. The locks were built of brick, with stone cutwaters, quoins, and coping. The framing of the gates was of oak covered with fir planking. The hollow and clap quoins were of cast-iron, which had long been in use on the Birmingham Canal, and was found to be preferable to wood or stone. All the boats passing through the canal were gauged in these locks.

For facilitating the construction of the tunnel, seventeen shafts were sunk, at intervals varying from 164 yards to 200 yards. The greatest depth of any shaft was 344 ft. 6 in., and the least 65 ft. 9 in.—the total depth of all the shafts being 3083 feet. No attempt was made to coffer out the water met with in the shafts. It was received in zinc gutters nailed to the curbs, and was conducted by a cast-iron pipe, fixed down the inside of the shaft and in a groove built in the soffit of the tunnel, to the back of the tow-path, under which it passed into the canal. The average rate of progress in sinking the shafts, counting only the days on which work was done, was 3 ft. 4 in. per day of twenty-four hours. The materials excavated were principally marl and bind; but coal and basalt were met with in several of the shafts.

The tunnel was 3036 yards in length. It was 27 feet wide, and 24 ft. 4 in. in height. The water-way had a breadth of 17 feet, a depth of 6 feet in the middle, and of 5 feet at the sides; and the height above the water level was 15 ft. 9 in. It was lined with brickwork throughout of uniform thickness, except in the side and shaft lengths, and where the ground was bad. In several places, where the foundation was blue bind or marl, the invert was forced up in the centre, owing to the swelling of the ground. This was not accompanied by any subsidence of the side walls, and although the brickwork was in some parts raised 5 inches it was not broken or crippled except at a point immediately south of No. 7 shaft. Here the invert had been forced up 8 inches in the centre, and some of the bricks were crushed almost to powder. In rebuilding this, the brickwork was increased in thickness, and in a small portion a greater versed sine was given to the invert. The trough of the canal in the tunnel was formed in a similar way to that in the cuttings.

The excavation and construction of the tunnel were carried on in the ordinary way. The heading was 5 feet by 3 feet, the bottom being level with the top of the intended invert. It was mentioned, that when the

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water was admitted the tunnel was found to have been executed in a perfectly straight line. This remark did not however now apply to a short length at the south end, where a subsidence to the extent of 10 inches took place from mining operations. Similar depressions, but of less amount, also occurred near No. 14 and No. 15 shafts.

When the construction of the tunnel was proposed, considerable diversity of opinion existed as to the nature of the strata to be passed through. On the geological map a mass of trap rock, locally called Rowley Rag, was shown, about a mile wide, at this point. But in the borings, some of which were close to the summit, no trap whatever was discovered. While the excavation of the shafts and tunnel was progressing, a careful record was kept of the strata passed through. With the exception of some apparently unconnected pieces, the only trap rock met with was a wall or dyke, about 8 feet thick, a little to the north of No. 7 shaft. From its inclination and position, this appeared to be the channel through which the trap rock had risen and spread over the surface. On the north side of the dyke the strata were principally marl, coarse sand rock, and a hard shaly clay known as blue bind. On the south side, marl and bind were likewise extensively found; but coal, bat, ironstone and fire-clay were also passed through.

The time occupied in the construction of the tunnel was two years and seven months. The whole of the works had cost £200,000, of which the tunnel, including the shafts, the canal, and the tunnel faces, amounted to £155,000. The tunnel alone cost about £39 5*s.* per lineal yard.

Feb. 14.—The paper read was "*On the Construction of Artillery and other Vessels to resist great internal pressure.*" By J. A. Longridge, M. Inst. C.E.

It was stated in the outset, that it was not proposed to treat of the very wide range of subjects involved in the construction of the most perfect description of ordnance, but to limit the inquiry to the question, how to make a gun of sufficient strength to enable the artillerist to obtain the full effect of the explosive compound used in it? This question was one which the civil engineer was probably more fitted to deal with than the artillery officer, inasmuch as it required nothing beyond a knowledge of the properties and laws of action of those materials with which his every-day practice made him familiar.

The attention of the author was drawn to the subject early in the year 1855. Following up the reasoning of Prof. Barlow on hydraulic press cylinders, he was led to consider how the internal defect of any homogeneous cylinder could be remedied. Prof. Barlow had shown, that in every such cylinder the increase of strength was not in proportion to the increase of thickness, and that a vessel of infinite thickness could not ultimately resist an internal pressure greater than the tensile forces of the material of which it was composed. The material at the internal circumference might, in fact, be strained to its utmost, when that at the outside was scarcely strained at all. To remedy this, it was necessary that each concentric layer of the gun or cylinder should be in an initial state of stress, such that when the pressure was applied the sum of the initial and the induced stresses should be a constant quantity throughout the whole thickness of the cylinder. It occurred to the author that this could be accomplished by forming the gun or cylinder of a thin internal shell or case, and coiling round it successive series of wires, each coil being laid on with the tension due to its position.

The principle of building up a gun in successive layers, with increasing initial tension, was therefore that which it was intended to bring forward in this paper. The author claimed no exclusive merit for this idea. Although then unknown to him, it was being followed up by Capt. Blakely, Mr. Mallet, and others, who however sought for its practical outcome in rings or hoops, contracted or forced on to the central core. Capt. Blakely had, equally with the author, the idea of making use of wire, although his experiments were entirely confined to hoops. It was in complete ignorance of what others were doing that the author undertook the experiments recorded and described in detail in the present paper. The results were so striking, that he lost no time in bringing them before the War Department. The usual reference was made to the Select Committee at Woolwich, with the usual result. The principle was pronounced to be defective, and not such as to warrant any trials at the public expense. The author however continued his experiments, and the results were such as entirely to confirm his confidence in the practical utility of the invention.

Before describing these experiments, the paper referred to the construction of guns as hitherto practised. It was first shown, from the author's experiments, that the strength of powder was about 17 tons per square inch. The system of rifling, involving elongated shots without windage, greatly increased the strain on the gun. This being so, it was not surprising that many attempts to rifle the ordinary guns had proved fruitless. Even independent of this extra strain, experience had shown that for heavy ordnance cast-iron was too weak; and it was believed that this was not owing, as had been stated, to any deterioration in the quality of the material, or to any want of honesty on the part of the contractors, but simply to more work being put upon cast-iron than it would bear.

Experiments on the direct tensile force of cast-iron must not be depended upon, when the material was cast in a huge mass like that of a 68 lb. gun or a 13-inch mortar. Neither could such experiments be trusted as regarded wrought-iron or steel. It was shown that the iron cut from the inner part of the Princeton gun was 50 per cent. weaker, as strained by the explosion, than the bar iron from which it was made. The same decrease of strength, though to a less extent, was found in the case of the great gun forged by the Mersey Iron Company, and presented by them to the country. Moreover, large masses of any metallic substance must always, it was believed, be subject to inequalities of physical structure, which rendered them untrustworthy for heavy ordnance.

These considerations led the author and others to the principle of construction already named. Capt. Blakely and Mr. Mallet sought to apply it by means of hoops, which under almost any circumstances gave an increase of strength. If correctly applied this increase was very considerable, but there were great difficulties in the application. Each hoop was itself subject to the same law as a homogeneous cylinder, and consequently a series of hoops was wanting in that uniformity of strain which was required. It was possible so to adjust the hoops that at the time of explosion the inner surface of each might be equally strained, but the strain on each hoop decreased to the outer surface, so that there was an abrupt change at the junction of any two hoops. Moreover, a very slight error in workmanship would produce a most serious effect. Taking for instance an 8-inch gun, constructed of four concentric hoops, the total thickness being 6½ inches, an error of $\frac{1}{100}$-inch in the size of the outer ring would reduce its strength by 43 per cent.

Wire, on the other hand, afforded the greatest possible facility of construction, and the coils might be laid on with the utmost accuracy as regarded tension, and with the same ease and regularity as thread was wound on to a bobbin.

The first series of experiments tried by the author were made with brass cylinders, 1 inch internal diameter and $\frac{1}{10}$-inch thick. Into these various charges of powder were put, and the ends hermetically sealed, The total capacity of these cylinders was 295 grains of powder. One of these cylinders was burst with a charge of 90 grains. Another exactly similar, but covered with four coils of $\frac{1}{33}$-inch steel-wire was uninjured by a charge of 200 grains.

It having been objected, that owing to the brittleness of cast-iron it would be impossible to use it in conjunction with wire, cylinders of cast-iron of the same size were prepared. Some of them were entirely filled with powder (310 grains), which was then exploded without injury to the cylinder. In this case the cylinders, which were $\frac{1}{10}$-inch thick, were bound round with ten coils of iron wire, No. 21 gauge, or $\frac{1}{25}$-inch diameter. The bursting charge, without wire, was 80 grains.

After this a small gun was made of cast-iron, covered with wire. The chase was 3 feet long, and the calibre 3 inches. The cast-iron at the breech was ⅜-inch thick, and decreased to ⅛-inch at the muzzle. Iron wire $\frac{1}{16}$-inch diameter was used, there being twelve coils at the breech, and four coils at the muzzle. The total weight of the gun, with its wrought-iron trunnion stock, was 3 cwt. With this gun, and an elongated shot weighing 7½ lb., and with 11 oz. of government cannon powder, a range of upwards of 1500 yards was attained, the elevation being 7°.

Another application of the principle was stated to be to the cylinders of hydraulic presses, and an instance was given of a cylinder of 6 inches internal diameter, made of cast-iron ⅜-inch thick, and covered with twelve coils of $\frac{1}{16}$-inch iron wire. This cylinder was proved up to 6 tons per square inch, when it gave way by the sides shearing off the bottom plate. The cast-iron was not shattered, nor was a single coil of the wire injured.

It was stated that these cylinders could be made at one-fourth the weight, and at about one-half the cost of the ordinary hydraulic-press cylinders; and that their lightness was of great importance when intended for export to South America and other countries where the means of transport for heavy machinery did not exist.

After the meeting, Mr. W. Strode, Assoc. Inst. C.E., exhibited and explained specimens of *Messrs. McKenzie and Wentworth's Breech-loading Rifles.*

The conditions sought to be fulfilled in these rifles were:—

1st. That they should be able to take the present ammunition.

2nd. That they should have a sound joint at the junction of the breech and the barrel.

3rd. That there should be nothing liable to be discharged against the soldier himself, by his own act, in case of bursting; and therefore no plug or stopper put in from the back or breech-end of the barrel.

4th. That the strength should not be less, and the weight scarcely more, than in the present guns.

5th. That the moveable breech should be capable of adaptation to any barrel, as well as to any form of ammunition.

It was stated that these rifles only differed from the Enfield pattern in the breech and in the "stocking;" so that if the changes were made which these alterations involved, they could be readily manufactured at the government establishment at that place. It was thought that such a weapon would be especially useful for Volunteer Rifle Corps, as muzzle-loading would not be necessary.

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WESTON RECTORY, SUFFOLK.

(With an Engraving.)

THE building of which we herewith give an exterior perspective view, with plans of the ground and chamber floors, is the design for a new rectory-house, at Weston, in the county of Suffolk.

The material employed is dark red and other coloured brick, with stone for the plinths, doors and windows, banding courses, strings, enrichments, and other such like worked portions. The roof will be tiled and banded with black and brown or Warwickshire tile. The exterior timber work will be of clean deal, varnished with a compost of pine varnish and Stockholm tar. The crocketting and finials of lead and galvanized metal. The interior arrangements are sufficiently indicated on the plans. It will be only necessary therefore, as regards these, to direct attention to the letters of reference. Of the offices only those more strictly relating to domestic use are shown. The stabling, &c. will occupy one side of the kitchen court, upon which the former are arranged to open.

The style adopted is an accommodation of the French Domestic of the latter part of the fifteenth century. The estimated cost is £1760: the architect, Mr. E. L. Blackburne, F.S.A., of Grenville-street, London.

References to Plans.

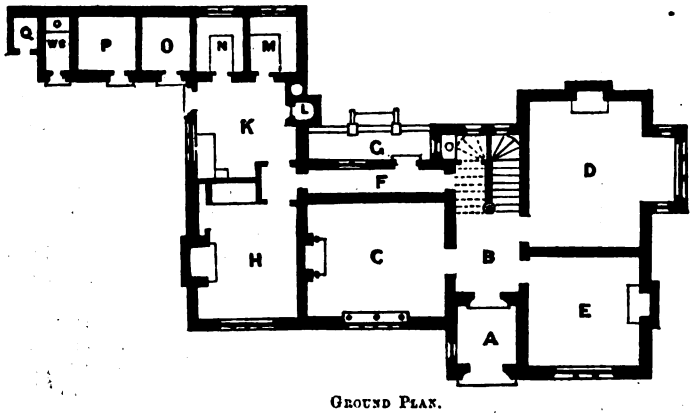
GROUND PLAN.

A. Porch or tower entrance.
B. Hall and staircase, W.C., &c.
C. Dining room.
D. Drawing room.
E. Study or library.
F. Passage to kitchen, &c.
G. Garden or back entrance and terrace.
H. Kitchen.
K. Scullery.
L. Oven.
M. Dairy.
N. Pantry.
O. Coal cellar.
P. Wood ditto.
Q. Dust.

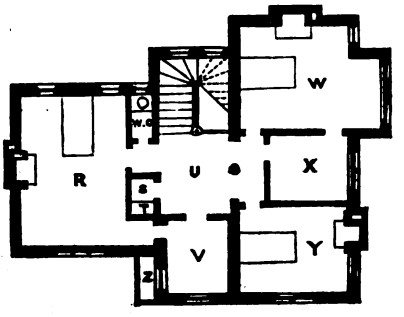
CHAMBER PLAN.

R. Principal bed room.
S, T. Housemaid's closet and sink, &c., with W.C. opposite.
U. Landing and corridor.
V. Dressing room to best bed room.
W. Second bed room.
X. Dressing room to ditto.
Y. Third bed room.
Z. Balcony.

The servants' rooms are above.



GROUND PLAN.



CHAMBER PLAN.

THE APPLICATION OF ZINC TO BUILDING PURPOSES.

By JAMES EDMESTON, Architect.

THE following remarks upon the qualities and application of zinc for building purposes have resulted from some steps suggested by the Vieille Montagne Zinc Mining Company, of Belgium, France, Sweden, and other places, with a view to correct erroneous impressions in this country respecting this material, by means of a patient and unbiassed investigation of the facts as they exist abroad. It was with some astonishment that I found the company mentioned equals some of our largest industrial undertakings in magnitude and importance, owning three collieries—besides its own mines of calamine and blende, and with large mining, smelting, and rolling establishments in Belgium, France, Germany and Sweden. At Liege, I visited a smelting-house containing thirty furnaces, which are constantly at work; and at Angleur I inspected an extensive establishment containing the stores of calamine and coal, and an enormous smelting-house containing forty-eight furnaces; 100 tons of coal are consumed daily at these works alone. In the seven large smelting establishments in Belgium and Prussia, comprising two hundred and thirty furnaces, 29,000 tons of spelter are produced, and 23,000 tons of sheet-zinc are annually made, besides about 7000 tons rolled at mills which are not the property of the company. In the three establishments for making oxide of zinc, about 6000 tons of oxide are annually manufactured.

It is said that the general consumption of spelter throughout the world is about 67,000 tons per annum, of which about 44,000 tons are made to take the shape of rolled sheets. Fifteen years ago the quantity used for roofing did not exceed 5000 tons per annum, the quantity now so employed is 23,000 tons; none was used for ship sheathing or lining packing-cases, and the stamped ornaments in zinc date only from 1852.

The company consumes more than 200,000 tons of coal in the year; in their various mines and establishments they employ 7000 workmen; and in plant and works they have invested three quarters of a million of money. The manufacture is therefore of great importance, and it occurred to me at once, that however much the article thus produced is despised in England, an enormous consumption, of which I had no previous conception, existed somewhere.

The success which has been attained is in a great measure owing to the admirable way in which the company has been managed. It is contrived that all employed, every official, from the managing director to the humblest workman at 2 francs a day, shall have some additional profit, according to the extent of the trade; and far from being contented with merely manufacturing sheets of zinc, which might be considered all that came within the scope of a mining company, they have made a practice of having workmen at their works a sufficient time to gain instruction in the peculiarities of the material, and these have been afterwards assisted and established in business in various towns, where they have risen to prosperous positions under the eye of the company. Gentlemen educated as architects have been engaged to travel from place to place, to supervise zinc work in course of performance, and to afford gratuitous assistance and advice where such work is contemplated, and by the extreme care thus taken to guard against mistaken use of the metal, it has risen so rapidly in estimation, that where it has obtained at all, it has wholly superseded all other metals for roofing purposes, indeed it may be said all other materials, for slates and tiles seem only to be applied with a view to effect in patterns or ornamental forms, or to the more inferior buildings.

The process of manufacture is very simple; the calamine (carbonate of zinc) is first calcined, by which it loses about 20 per cent. of its quantity, it is then ground in a mill, and mixed to the extent of one-third of its bulk with powdered coal, to assist the smelting; the whole being much moistened: this mixture is put into the smelting pots, and these at six o'clock every morning are placed in the furnaces. At six o'clock in the evening, that is, in twelve hours, the smelting is complete; the metal is drawn out and run into metal moulds: it then goes into the rolling-house, and is again melted and recast in a metal mould to produce ingots of the proper size and weight for the required gauge of the sheets to be rolled—this second melting is also desirable to obtain proper purity.

Purity in the metal to be used for building purposes is impor-

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tant; if there is much impurity no after-care will be of any avail. For ship sheathing—and zinc is now very largely used for this—this is very essential, for it becomes immersed in a downright galvanic bath; and if iron be present in even a small quantity, or lead, it would quickly destroy itself. This is not so much the case in roofs, but purity is most desirable; and impurity may exist to an extent sufficient to spoil the best constructed roofs, and in many cases has done so beyond doubt.

Attention to a few simple but never-to-be-overlooked necessities of construction is absolutely necessary to avoid certain loss and disappointment in the application of zinc for building purposes.

Almost all the replies received to my inquiries here were condemnatory; though in the majority of them this was not the result of personal experience, but of a strong impression founded rather upon general report and opinion.

Some instances of failure were brought before me, and these were mostly,—crumbling to pieces; black spots appearing, supposed to be the effect of London atmosphere; holes and wearing out of the metal in a short time;—all these would arise from impurity in the metal, or from contact with iron: cracking in places; soldered joints parting; drips or joints failing in flats; tendency to buckle and to have an untidy appearance in consequence, and general unsoundness of the work;—all these would arise from bad construction.

A sheet of zinc of proper purity is very easily distinguished from an impure one: it will be of an even colour, without black spots or blotches—very ductile, and easily bent backwards and forwards in the hand: will not easily break. And if impure it will be the opposite of all this; if there is any iron in it, it is worthless, and black spots and brittle texture will demonstrate this: if it contains lead in any quantity, it will still, though to a less extent, contain the germs of destruction within itself. The oxide of lead is very soluble in water, while the oxide of zinc is not. I don't know how better to prove this last assertion than by referring to a piece of zinc in my possession, cut by myself from the roof of an old house adjoining the smelting works at Liege—this is a Mansard roof, formed in 1813, and is the earliest example I could discover; at that time the house was occupied by M. Mosselman, the original proprietor of the first mine of calamine possessed by the company. The metal is thin, only No. 12 gauge (17 oz. to the foot), it is evidently very pure, and is evenly coated with a thin, hard oxidation, which has penetrated but a very little into the metal: it requires the assistance of a hard tool or chisel to remove the coating. This roof is in the midst of foundries and works consuming coal, it is attached to the smelting-house, and much sulphur is given off in the fumes from the furnaces; it is one of the first, or it may be the very first existing roof of zinc in Europe, for it has stood forty-six years; it is not laid in the best way, being without wooden rolls, but still, so as to leave the sheets quite free; the gutters are of lead, which is very unusual in more recent works. I found this roof evenly and perfectly sound with one exception, and that was where it was confined by soldering to the lead gutter. I cut off a piece of the defective part, and, in my opinion, the soldering by which the metal was confined accounts for the injury in that part; a piece of the zinc thus injured has been carefully examined by M. Baresville, chemist, of Paris, but he reports that his analysis gives no results justifying the opinion that any galvanic action between the metals in contact had taken place, and indeed the contact with lead gutters is known to affect the zinc in ordinary cases hardly at all: in this case, however, it was not mere contact, but absolute cohesion by solder, and the injury certainly appeared to come from the underside, where the solder seemed roughly put on in large quantities. The zinc may have been injured and burnt, and so have been rendered doubly liable to suffer by the confinement, which is always most injurious to it. M. Baresville, in the course of his report, and in allusion to the apparently unaccountable manner in which under some circumstances any metal may be affected, without any very certain explanation being possible, mentions the surprise with which on one occasion the leaden bottom of a reservoir was found to be perforated and converted into absolute white lead: the chemists who were called in suggested that the sugar from the subjacent wood had formed itself into an alcoholic fermentation, that the alcohol had turned into vinegar, and that the acetic acid, absorbing the oxygen of the atmosphere, had become the destructive agent—an explanation which he says is possible, but not altogether likely.

I have one other instance of an old roof, but not so good, because more recent. At the house occupied by Mr. Van Hoorde, at Laeken, near Brussels, is a zinc roof, erected in 1821; thirty-eight years in existence therefore. The specimen cut from it shows it to be thicker than the other sample, being No. 14 (21 oz.); the oxidation is quite on the surface, and is hard, and as before difficult to remove. The first of these roofs had never been repaired within the memory of any one, in fact it was forgotten, and was only thought of in consequence of my refusal to consider the numerous modern roofs to which my attention was called as proving anything which would clear up uncertainty here; the roof at Laeken was quite sound, but it appeared that improper nails had been used, these had given way, and some of the sheets had slipped in consequence. There is however another example at Laeken—a large flat, soldered all over so as to be in one piece; it is full of undulations, never in order, and constantly being repaired, in spite of the first-rate quality of the zinc; giving as strong a proof as possible of the way in which ignorant construction will ruin the best material.

But even if the zinc contains no iron, the contact of iron, where a little confined damp may exist, will be quite as injurious, I cannot find that this is understood here, iron nails are commonly used for boarding under the zinc, and if a nail head is in contact, and there is damp, in three months a hole will be eaten through. Generally speaking, for the best roofs on the continent zinc nails are used for the boarding; and all iron work where necessary, and if used at all, is galvanised. Or where iron nails are used for boarding they have small heads, and are hammered well into the wood so as to be buried, and a little cement or stopping is frequently rubbed in over them; practice has found that the nails thus used rarely do any mischief, and as the zinc nails require certain care and take more time, and are dearer than the iron, I found that in Paris at all events the iron were used frequently, but always with the above precautions. I could not discover that the contact of lead was injurious, but it is considered to be better avoided. Impure zinc being brittle will crack when turned up against the rolls, or it will break off entirely, and the builder who saves something in first cost is quite likely to lose more in the end from waste.

The second set of defects to which I have alluded, and other modifications of them, will be referable to ignorant construction; none of them exist where proper knowledge has been exercised in this respect, and the one object to be kept in view is to permit *perfect freedom to the sheets*, to confine them nowhere, and to separate lengths of guttering, and any other portions of a roof requiring to be made in long pieces, as much as possible. The junctions of sheets covering flats which have but little fall, and the joints in gutters, are the only parts which should ever be soldered, but in long lengths there should be drips in flats and gutters: the laps may be made according to the usual mode of connecting sheets of zinc in roofs and sloping flats, and they should be somewhat deeper than the drip for lead: fillets with chamfered edges are better than round rolls, and those in Belgium are chamfered so as to be narrower on the underside, thus giving rather more play to the sheets. Confinement is the sole cause of unevenness in the sheets, this never takes place in sloping roofs; it is more possible in flats, but will hardly exist then if the sheets are free. Very few absolute flats however came under my notice, and a moderate slope seemed to be generally adopted.

Eaves gutters should be made in short lengths, bent in the direction of the way in which the sheet has been rolled and soldered; the solder put between the sheets, and one sheet lapping over the other; they must not of course be screwed to the rafter's feet—a practice, by the way, which occasions a constant failure in the joints of iron eaves gutters. Wherever a down pipe comes there should be a stopped end in the gutter, and the gutter should never be continued longer than possible in one piece; where it is laid behind a parapet, as in all the new and magnificent buildings in Paris, a separate piece of flashing will disconnect it wholly from the sheeting on the roof. For guttering, the gauge used should be increased in proportion to length, say No. 14 for 10 feet, No. 15 for 20 feet, and so on up to No. 18. There should be a proper substance in all cases. No. 14 is ample for London; in Germany it is customary to use a less thickness.

The choir of the cathedral at Cologne is covered with Silesian zinc. The old lead was defective and was removed, and the zinc substituted by Herr Zwirner in 1829. The gutters are zinc, it is laid in the old way without wooden rolls or fillets, as is the

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custom still in Germany. Herr Zwirner, the architect to the Royal Commission, informs me "that zinc is now commonly used for roofs in the whole of Germany," and that all his practice has taught him "the solidness and closeness of a well constructed zinc roof."

Oak boarding will spoil the zinc, and the fir should be dry; the boards laid with an aperture of about half an inch between each; if they are damp, as much oxidation will take place on the underside of the zinc as on the top of it.

A good way of laying flats in some situations is without rolls, but with sunk gutters between the sheets, with in fact inverted rolls, which form gutters; for London, however, I would recommend the ordinary way, as the small gutters are liable to be filled with blacks and soot if neglected. In forming laps care must be taken to prevent the water from ascending by capillary attraction—there must either be space enough to prevent the drops thus rising, or the end of one sheet must touch altogether, and that of the other be kept well away, and this is found the best mode, and the least open to careless treatment by workmen.

The thicker the zinc the less its expansion and contraction. In a report made to the Academy of Science by the Director of the Conservatoire des Arts et Metiers, a government institution existing in the Rue St. Martin, to inquire into scientific inventions, civil engineering, and all constructive science, it is stated as follows:—"It appears from actual experiments that the oxidation proceeds for about four years, gradually diminishing after the first three months, and that it then hardens into a protecting coat ('email') of a dark grey colour, preserving the metal beneath from any further deterioration." And it concludes by saying "that it becomes evident that as a sheet of zinc exposed to the atmosphere for a series of years loses little or nothing of its weight or thickness, and as its surface remains hard and polished like enamel, it may be fairly deduced that the following years are not likely to occasion any alteration, and therefore that zinc will be placed in the same condition as bronze, which is protected by its 'pattine' for ages."

The Vieille Montagne zinc is very largely used for ship sheathing, for which purpose its duration is said to exceed that of copper. Seven hundred ships had been covered with it in France alone, and double that number in England, as early as 1849. It is largely applied to the manufacture of stamped articles in great relief,—brackets, mouldings, ornaments of all descriptions, and especially the "marquises" or ornamental projections forming the shop fronts and entrances to the cafés in Paris,—for these purposes proper purity and extreme ductility are of course indispensable; this zinc is always quoted in the market at about £2 per ton higher price than any other. It would be impossible to pretend to give any list of buildings to which this covering is applied in Belgium and France—it would prove nothing to enumerate works done during the last fifteen years, except that it has gained the full esteem and approval of the most eminent architects and engineers of those countries; the general opinion seems to be that once properly done no limit is yet ascertained to its duration; tiles and slates are always after a few years wanting attention and repair, and when once this is begun it continues constantly;—zinc roofing once well done, it is said, wants none; and this is the great recommendation urged in its favour. The factories and works in the iron districts of Belgium, the railway stations in France and Germany, the public buildings and private houses throughout Paris, may in all directions be seen with roofing of this material. If an old house is added to, zinc is the roofing for the new part; if an old tile roof is worn out, zinc is certain to supply its place.

The great charge brought against it in England is that it will not last, and therefore no amount of recent facts would avail to set that question right. I may, however, allude to the magnificent new markets for Paris, constructed of iron, under the direction of M. Baltard, architect, in 1856; these great roofs are covered wholly with zinc, No. 14 gauge, the gutters being No. 16, the whole in perfect condition, except in one place, where some undulation has occurred in consequence of the workmen having confined the metal by solder, very needlessly, because a little extra labour was necessary to lay the zinc properly. The down pipes are of zinc No. 14. Also the entire roofs of the magnificent houses forming the Boulevard de Sebastopol, the new mansions in the Champs Elysées, the new part of the Louvre, in which the flats are of zinc, and the curbs only of slate. The roof of the Hotel de Ville, the roof of the Church of St. Clothilde, and in fact nearly every roof formed in Paris within the last fifteen years. Among the older roofs in Paris I inspected that of the old Palais de Justice, laid with zinc in 1832, with lead gutters. I saw the workman who had been employed, and he informed me that the roof had never been repaired during the twenty-seven years of its existence; it is corrugated, soldered at the ends of the rolls of corrugation to the lead ridge and hips, it is quite open to view on the inside, and is now as perfect as the day it was put up. The roof of the Museum in the Jardin des Plants, laid in 1835, in small pressed sheets, corrugated, about 12 inches by 14 inches each, is quite sound, and though not done on a good plan has every appearance of being likely to retain its perfect condition.

A zinc roof becomes cool more rapidly than slate or tiles after a hot day, for this reason it is applied to the roofing of cooling vats in breweries and distilleries. The Vieille Montagne Company have formed several zinc roofs in Algeria, and are now covering a palace for the Sultan at Constantinople; the great heat of the sun in those countries is not found to be injurious. I also saw in course of construction, for the Pacha of Egypt, a house of iron framing, entirely covered with zinc: every moulding, and the arabesque ornaments of a very elaborate character, were all in zinc. I should mention, that while cement does no injury to the zinc, the lime of Paris destroys it, and that when cisterns or other zinc constructions are confined with brickwork, in mortar, the custom is to fill in round them with earth, so as to protect the zinc from the lime.

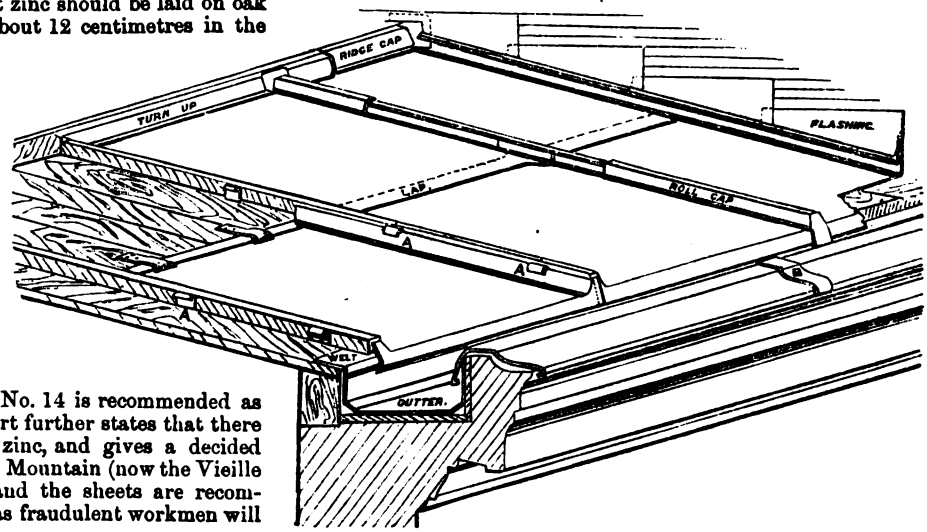
It is said that calcareous water injures zinc cisterns, which is very probable; and I have been informed, that when the late Mr. Burton built St. Leonard's-on-Sea, the zinc gutters had all to be removed after a short time, and replaced with others. There are many very extensive roofs situated at the sea-side: for example, the government buildings at Toulon, at Cherbourg, at Rochefort, at Brest, Marseilles, L'Orient, and Le Havre, which have been in existence for an average of some fourteen years; and more recently, the Chateau Eugenie of the Emperor, at Biarritz: in one case only had there been a failure, and the facts are curious. It is the custom to lay boards beneath the zinc in a properly constructed parapet gutter, but it is nevertheless a common practice to lay only brown paper beneath it, and to omit the boards; the sole object desired in either case being to prevent contact between the zinc and the plaster or lime; the brown paper in fact, as long as it remains dry—and under ordinary circumstances it cannot easily get wet—answers the desired purpose. One of the gutters to a long roof at the docks at Le Havre was found to fail, while all the others fixed at the same time remained perfect; every effort was made to find a reason for this, but without any scientific solution being obtained. Upon taking up the gutters however, it was found that while all the others were laid upon boards, in the defective length these were omitted, and the brown paper had been substituted; this it was found had decayed, and the only explanation of the circumstance which could be suggested was, that sea-water had been used with the plaster, that this had damped the paper and caused its decay, so that the zinc came in contact with the plaster, which plaster further contained the salt of the sea in its composition, and had speedily effected the destruction of the zinc.

A parallel has been drawn between the duration of zinc plated or "galvanised," as it is commonly called, upon iron, and that of the rolled sheets, but none can properly be made. The deposit upon the iron is a layer of zinc in the nature of a cast coating, and is probably very crystalline in its formation; whereas in the rolled sheets the crystalline nature of the metal is altered, and it is rendered fibrous and closer and more compact in its texture.

Much has been said as to the probable influences of London atmosphere impregnated with the fumes of coal. It is curious to observe that in Paris, zinc flues and chimney cowls, so common in London, are never used; a building however came under my notice in which there were three zinc pipes or flues, two about 30 feet long direct from the coal fires, and a shorter one terminating a brick flue, and much more distant from the fire itself, where wood was burnt. The zinc flues from the coal fires remain now, and have stood for some ten years; but the flue from the wooden fire perished in a year after it was fixed, was renewed, and the second one perished also. Is it that the pyroligneous acid is liberated in the burning, and destroys the zinc? Such is the suggested explanation, and there may be a great mistake in supposing that the atmosphere charged with smoke from wood is less injurious than where coal is burnt: it is however very clear that there is a good practical reason why chimney flues of zinc are in bad repute in Paris.

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The report of a commission appointed by the Central Society of Architects in Paris, in 1855, recommends that zinc, which was at first rejected but is now so generally used, should be applied with great care, as certain precautions, very simple but never to be overlooked, are indispensable. Thus, contact with plaster, which contains a destructive salt, is to be avoided; also contact with iron, which is very injurious, and liable to cause a rapid oxidation. Eaves gutters should always be supported by galvanised brackets; and no gutter or sheet zinc should be laid on oak boards. A fall is recommended of about 12 centimetres in the metre—say 14 inches in 10 feet; and No. 14 is recommended as the best thickness for roofs. The report further states that there is great variety in the quality of the zinc, and gives a decided preference to that of the Old and New Mountain (now the Vieille Montagne Zinc Mining Company); and the sheets are recommended to be stamped in the middle, as fraudulent workmen will sometimes cut off the stamped corners.



ROOF IN THE VARIOUS STAGES OF COMPLETION.

A. Clips to hold the sheets passing under the wooden fillets.
B. Junction without wooden roll.

The use of zinc wire instead of iron wire (which so soon perishes) for the guards to church windows is strongly recommended, and the cast and stamped ornaments, which are very extensively used, are spoken of with great praise. The application of the old metal for casting and for manufacturing the white of zinc is stated to have given it a rapidly rising value. The stamped ornaments belong almost exclusively to Paris, while in Berlin the cast ornaments are manufactured very largely.

A report was made by Dr. von Petenkoffer at the request of the directors of the Bavarian Railroad Commission. He was required to answer this question:—"What is the necessary thickness of zinc upon iron in order to preserve the latter metal from oxidation?" He obtained a piece of zinc from the roof of a building in Munich which had been exposed to the atmosphere with very small traces of oxide of lead and iron; he calls it an oxyhydrocarbonate of zinc. He made experiments to ascertain the action of the rain water, and concluded that the zinc in 27 years had lost the five-thousandth part of a "line"* in thickness, about two-fifths of which he considers to be carried off by the atmospheric waters of condensation, while the other three-fifths remained as hard oxide. His experiments, therefore, would in a small degree negative the theory that the oxide is a *full* protection to the zinc beneath; but, he says, it is clear that the destruction proceeds extremely slowly, and most likely becomes slower as the oxide becomes thicker; he observes that a sheet, 0·25 of a "line" thick, would last 243 years if equally affected always, but as it would be unequally affected, no doubt a less period would practically be the duration; he found the oxidation at its greatest depth to have penetrated a tenth-part of the original thickness of the metal.

In the face of all these facts and careful independent inquiries, it seems impossible longer to contend that zinc is other than a valuable and excellent material for building purposes, too important to be overlooked, and worthy of a more extended use and of a better appreciation than it has yet received with us. Some of its advantages are the facility with which rooms in the roof are obtainable, the convenience of being able to cover extensive areas with a material so light and so easily carried, by which heavy trussing and great strength in the supports is avoided, the ease with which a repair is effected or an examination made in a properly-constructed zinc roof, each part taking to pieces, and being again replaced without any injury or disturbance to the rest.

There is a current opinion that animal deposits, such as result from the congregation of cats on a zinc roof, are exceedingly injurious. I can only say that there is no lack of cats in Paris,

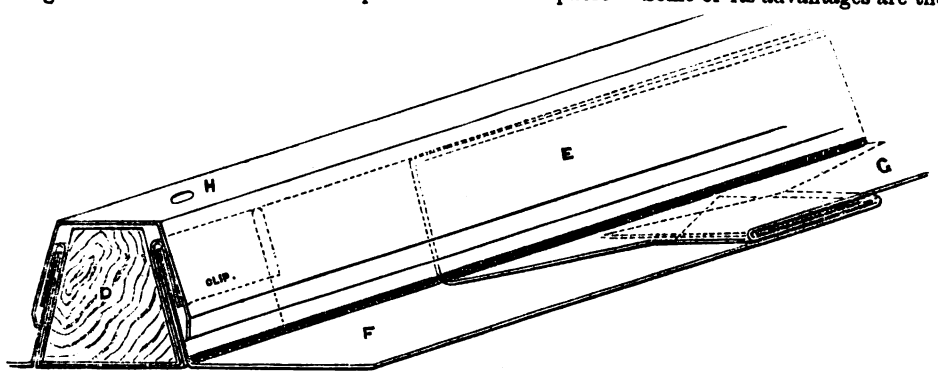
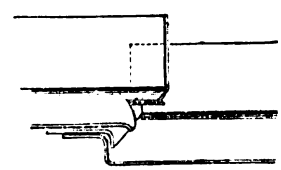


DIAGRAM SHOWING THE ROLL COMPLETE, WITH ROLL CAP, FOR A SLOPING ROOF.

D. Wooden fillet or roll.
E. Lapped junction of sheet.
F. Under sheet.
G. Upper sheet.
H. Oval hole for the nail or screw to pass through with washer of lead or zinc under nail or screw-head.



DRIP IN GUTTER.

twenty-seven years: both sides were oxidised, the uppermost however more than the lower side. He found the oxide very tenaciously adhesive to the zinc, and impossible to be scraped off with the finger-nail, so as to expose the clean metal to view. This oxide was quickly soluble in warm water and potash (one part potash to six of water), and having with this removed the oxide, he found, microscopically, that the metal beneath exhibited a crystalline or uneven surface, a proof that the oxide had penetrated unequally. He observes that it is therefore of some importance as to whether the structure of the metal be of larger or smaller crystals. The oxide was found to consist of five parts oxide of zinc, four parts carbonic acid, and eight parts water,

* A line is ·086 of an English inch.

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that I made special inquiries as to this, and examined roofs bearing evident traces of being infested by these animals, but without being able to ascertain that they did any harm to the zinc; no one in fact seemed to have heard of such a possibility.

It may be supposed that zinc is so much used in France only because of a saving in cost, and that slate and lead are dearer. In the brick country, where there are plenty of plain and pantiles, but where zinc roofs are nevertheless used, it must of course be much more expensive. In Paris the facts appear to be as follows. In the first place, in consequence of the greater demand, zinc is £3 per ton dearer at this time in Paris than in London. A zinc roof at the above price per ton costs when laid £2 15*s.* 6*d.* per square of 100 feet in Paris (measured over the rolls as if it were all flat). Lead in Paris laid costs about £34 per ton, and the proportion between the costs of the two materials in the two countries is therefore much the same. Slating, with the Brittany slates, cost 4½ francs per metre, or 33*s.* per square, or with English slates £2 per square; the extra price of labour brings the final cost of properly constructed zinc work to nearly the same in London as in Paris, that is, to £2 15*s.* per square. It is clear therefore that the cost of slating in Paris is sufficiently below the zinc to contend with it successfully, and that it is only because of the far better and more lasting qualities of the latter, above all the annual saving in repairs, which has enabled it to take its present position.

In comparing cost between an ordinary slated roof in England and one of zinc, deductions for saving in timber, in thickness of walls, in lead, gutters and ridges, in heights of chimney stacks, party walls, &c. must all be reckoned—it is not very easy to give any absolute rule—in some cases the zinc roof or upper story will be a saving on the whole, in others the contrary, the extent to which it may be applied will not be effected either way in my opinion by this; the question so far as all ordinary dwelling-houses are concerned will turn upon the superior qualities of this sort of construction for durability and soundness; if it be found really to possess these qualities there is nothing in the cost likely to interdict its use; if it does not possess them, certainly the saving in some cases to be effected will not compensate for their absence.

Zinc is not one-third the cost of lead for flats and gutters, and for covering railway sheds and other constructions of similar magnitude it is by far the most economical material that can be used.

The treatment of zinc architecturally is yet in its earliest infancy, the plain sheets will without doubt in due course be stamped and ornamented with patterns or diapers, the rolls will be stamped with suitable running patterns, and all visible parts of zinc construction in buildings where ornament will be suitable, will in due time receive it, at little cost and in every variety.

REVIEWS.

A Manual of the Steam Engine and other Prime Movers. By W. J. Macquorn Rankine, C.E., LL.D., F.R.S., &c. &c.—London and Glasgow: R. Griffin and Co.

This is one of the most important books that have been brought under our notice for review for a long time past. In a former number of this Journal we pointed out the limits which are imposed on the deduction by pure analysis of scientific facts from first principles; a limitation which arises not from any essential impossibility in the nature of things of deducing those facts,—not from any want of continuity in the chain of cause and effect by which such results are connected with the first principles on which they depend; but simply from the imperfection of our system of analysis, which hitherto has been found unequal to the task of performing the required calculations. In the science of mechanics especially we find this to be the case; we start with certain equations of statical or dynamical equilibrium, applicable to imperfectly or perfectly rigid or fluid bodies, the degree and nature of the rigidity of which are expressed by arbitrary constants involved in the equations,—and these constants being given, all the complicated phenomena of the motion and equilibrium of fluid and rigid bodies ought to be able to be deduced as infallibly as the answer to a sum in the rule of three or of vulgar fractions. The form assumed by a mass of jelly poured out upon a table, and the time it would take to flatten down into its equilibrium form, ought to be capable of being calculated; and yet who would be bold or foolish enough to attack such a hopeless problem? But although analysis is incapable of travelling over, inch by inch, every stone and grade in the rugged up-hill path between the observed effect and the necessary prime cause, she can frequently step in half way; she can start from certain observed secondary laws, and with these as data generalise most usefully and establish important theorems, which shall enable us at once to predict and state a vast train of consequences, without being at the trouble of experiment in each particular case, and thus save us an enormous amount of labour which would otherwise be wasted in merely empirical research. And it is here that Prof. Rankine's book is so invaluable to the scientific engineer: it presents him with an admirably collated and selected mass of secondary principles and results, and thus enables him to solve upon paper almost every problem which can arise with regard to the relation between power and effect, necessary strength of material, &c. in the various machines he may be called upon to construct. But let Mr. Rankine explain the object of his work himself. We will quote his preface.

"The purpose of this book is to explain the scientific principles of the action of 'prime movers,' or machines for obtaining motive power, and to show how those principles are to be applied to practical questions.

It has been deemed advisable to prefix to the treatise a very brief historical sketch, relating chiefly to the steam engine, the only prime mover whose history is known. The body of the work commences with an introduction, treating of principles, and of mechanical contrivances, which are common to all prime movers, and of the laws of the strength of materials, so far as they are applicable to those machines. Some passages in the introduction are extracted from a previous treatise on Applied Mechanics, and abridged or amplified as may be required, in order to suit the purpose of the present treatise. Such passages are indicated by the letters A. M., with a reference to the number of the corresponding article in that work. The first part following the introduction treats of the use of muscular strength to obtain motive power. The second part treats of prime movers driven by the motion of water and of air, including water-pressure engines, waterwheels, turbines, and windmills. The third and largest part treats of engines driven by the mechanical action of heat, and especially of the steam engine. It explains, in the first place, the phenomena of heat, so far as they affect, directly or indirectly, mechanical action in engines; secondly, the laws of combustion and properties of fuel, and the principles upon which economy of fuel depends; thirdly, the laws of the action of heat in producing motive power, or 'Principles of Thermodynamics,' as applied to the various engines in which that action takes place, and especially to steam engines of all varieties; fourthly, the nature and action of the parts of furnaces and boilers; fifthly, the nature and action of the mechanism of steam engines. The fourth part explains the principles of the action of electro-magnetic engines; but very briefly, in consideration of their small importance as prime movers, and absence of economy; the true practical use of electro-magnetism being, not to drive machinery, but to make signals; and the subject of telegraphy being foreign to the purpose of this work. The principles of thermodynamics, or the science of the mechanical action of heat, are explained in the third chapter of the third part more fully than would have been necessary but for the fact, that this is the first systematic treatise on that science which has ever appeared; the only previous sources of information regarding it being detached memoirs in the transactions of learned societies, and in scientific journals.

The experimental and practical examples used to illustrate the application of the principles of that science, and of rules and tables deduced from them, are to a considerable extent taken from the author's personal observations of the performance of marine engines.

At the end of the book, as well as interspersed through it, are various tables, useful in calculations respecting prime movers, especially the steam engine; and many of those tables contain results which have never before been published."

We shall not in this month's number of the Journal attempt anything like an analysis of this very valuable book, as it has come to hand too late to allow of much more than a cursory glance at its contents, but although we are not prepared as yet to estimate nugget by nugget the carat fineness of the gold before us, we have seen quite enough to convince us of the richness of the mine, and to sharpen our zest for a more detailed exploration of its treasures. The truth is, anything like a conscientious analysis of the great amount of information and mathematical investigation which is presented to us in these 560 closely printed pages, would involve the labour of months, and although in the next number we hope to be able to give our readers a more definite idea of the subject of our review, we warn them that at the best it will be but a mere outline sketch of unquestionably one of the most valuable books in connection with engineering science that has ever been presented to the British public.

In concluding these prefatory remarks we would earnestly impress upon British engineers the extreme importance of making

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themselves familiar with mathematical investigation, an acquaintance with which will save them much loss of time, labour, and money, in making experiments to determine what calculation could just as surely have foretold, and also of material, which is frequently wasted through ignorance of mechanical principles. It is true that many of our greatest engineers have been destitute of theoretical knowledge, but how much greater might they not have been had they possessed it. In Prof. Rankine's book we find that most of the secondary data of mechanics are due to the experiments of the French engineers; the French in the science of engineering, as in all other sciences, taking the lead: had they the same command of raw material as we have, they might be very dangerous rivals to us. Let our engineers therefore bestir themselves, if they do not wish to be outrun in the race with their foreign competitors, now that these will no longer be weighted with the onerous load of protective duties and conservative prohibitions.

A Practical Treatise on Sewage and Drainage. By L. H. Isaacs, C.E. 6 plates.—Published by the author, Verulam-buildings.

This is an exceedingly clear and able treatise, conveying in a small compass a considerable amount of information upon the principles that should regulate the disposal of the sewage of towns and buildings, and the forms, sizes, and best means of constructing the sewers and drains designed to effect that purpose. The author disclaims any attempt to introduce novel theories or views in reference to the subject, and has incorporated with his own observations such of the principles advocated by the best authorities as have been proved to be practically correct, and which from his own experience he can endorse and recommend. No member of a district board of works should take his seat at the board without the possession of such an acquaintance with the subject of this treatise as would enable him to discharge his duties with benefit to the public. The author is Surveyor to the Board of Works for the Holborn district. Officials seldom become public teachers, but when fitted by scientific attainments and experience, they must be the most practical instructors upon the subjects in which they are engaged.

On the *ventilation* of sewers we find the following remarks:—

"There is no detail which has evoked more discussion, nor, at the same time, one in regard to which more ignorance prevails. Even those to whom we might expect to turn for information and guidance on this point are at fault; yet the doctrines they have promulgated have been received without questioning their correctness, and the errors contained therein have become, so to speak, stereotyped. Perhaps this is not to be so much wondered at when the difficulties surrounding the subject of ventilation generally are remembered; and if we reflect that the vitiated air generated in our public buildings is in very few cases successfully carried off, it can hardly excite surprise that the gases engendered in a complex system of sewers have hitherto baffled our efforts at removal. At the present moment the appliances used are of the most primitive character, and they strike us as being no nearer a solution of the question, how best to ventilate our sewers, than to point to a hole cut in the top of an Irishman's cabin as a satisfactory answer to an inquiry as to the most perfect means of conveying smoke from our dwellings.....It will be admitted, even by those who are most indifferent to any improvement in sewer ventilation, that the method at present in use is but a slight palliative of the evils of the former system, and that we have only succeeded in removing the stench from the footways to the centre of the road.

Various remedies have been tried, and still more have been suggested. It must be borne in mind that there is a gas to be met with in the sewers in no way connected with their contents, and for whose presence the latter are not accountable; we mean the coal-gas supplied to our dwellings by mains of various sizes, the leakages from which not only permeate the ground in which they are encased, but also the sewers below. These leakages are in fact producing a nuisance of a very serious character, and one which at no very distant date must force itself upon our attention, through the magnitude of the evil it is creating. It is but necessary to stand over any of the trenches so frequently made in the public thoroughfares, to be satisfied that this gas leakage is slowly but steadily reproducing the evils inherent in our former system of cesspools, and is bringing the upper crust of our towns and cities to a condition that has well earned the distinctive title of the pest stratum. Now it must be apparent that the improvement of our sewers will not remedy this leakage from the mains, nor remove the gas accumulating therefrom; added to which, the amendment necessary to bring about this improved condition of the sewers would necessitate in very many cases their entire reconstruction; and we are stopped at once from considering this any further by the conviction that its cost places it beyond the pale of practicability... ..Suggestions have been made at various times to make the rain-water pipes assist in the ventilation of sewers; and in Paris, and some few towns in England, the officials in charge of the sewers have endeavoured to carry the proposition into practical effect; but although it is undoubted that the emanations from the street gratings have been lessened in consequence of the extra height of the rain-water pipes directing the current towards them, this result has been attended by the creation of a nuisance of a serious character..... The evil is, that the vapour carried off by the rain-water pipes is emitted at such a level that it becomes a nuisance to the occupiers of rooms in the upper stories of our dwellings. It has been suggested to carry the pipes to the tops of the chimney-stacks; but it has been found that in certain conditions of the atmosphere the vapour has descended and has been conveyed by the flues to the rooms below.

The experience gained by testing the practical value of the two last suggestions has led to the supposition that the effluvium could be conveyed to a point sufficiently high to prevent its descending to the annoyance of the inhabitants, by means of large chimney-shafts specially constructed for the purpose, in suitable situations, and carried to a greater height than that of the surrounding buildings. The main point to be ascertained before a decision can be arrived at in regard to this proposition is, whether there is a sufficient difference in temperature between the external atmosphere and that of the sewers to create a constant current from the latter of sufficient strength to overcome the opposing force of the former. On this head a considerable amount of information may be gained, by referring to the tables of temperature in the appendix to a report upon the ventilation of sewers, by Mr. Haywood, the engineer to the City commission. In these tables are recorded observations made in sixty-five sewers in different parts of the City during all seasons of the year; and as they are evidently taken with the care usually bestowed by Mr. Haywood on the matters upon which he reports, they may be regarded as a fair average of the temperatures of sewers as ordinarily ventilated. An inspection of the tables will result in the conviction that during the period of the year when the nuisance from the sewers is the greatest, and the influence of these shafts would be most required, they would be inoperative and useless.

Thus we seem to want some additional power to draw off the deleterious gases which the sewage channels contain, for in the various suggestions we have considered, we have been unable to satisfy ourselves that they would not fall short of the purpose for which they were intended, or completely attain the end for which they were designed.

This additional power, we believe, can only be obtained by the application of artificial heat, supplied by furnaces attached to the chimney-shafts, whose probable action we have just been considering. Although in this as in all other appliances suggested for the ventilation of sewers, very many difficulties would have to be overcome before success crowned our efforts, we are of opinion there is greater probability of its being attained by this mode than by any other.

There are two objects which strike us as being necessary to be effected by any system of sewer ventilation which would claim to be perfect; first, to create such a draught that the air in the sewers may be conducted to any number of spots we may determine upon; and secondly, to deprive it of all health-destroying properties, so that in the event of its descending after its release into the external atmosphere, it may have been rendered innocuous and inodorous. We believe that artificial heat is as yet the only known agency by which these desiderata can be obtained, and we conclude our observations on this head by stating it to be our conviction, after a careful consideration of the subject, that the only practical method at present at our command, efficiently to ventilate the sewers, is by chimney-shafts with furnaces at their bases through which the vitiated air shall be made to pass as soon as it is collected."

Respecting *flushing* the author writes:

"In certain situations the practice of the flushing system is scarcely honest. In the higher parts of London, where the main sewers do not discharge immediately into the river Thames, but simply convey their contents to sewers at a lower level, ultimately finding their way to that great cesspool, it must be quite clear that the system of flushing can only be practised at the expense of the neighbouring districts, since all the accumulated matter in the sewers of the higher level must be forced into those of the lower, the inhabitants of which are thus saddled with the expense of removing their neighbours' as well as their own sewage. For these and other reasons that we could adduce, we are not disposed to subscribe to the supposed merits of cleansing sewers by flushing, and we can only admit the system as a palliative of one of the many evils which an originally erroneously devised system of drainage has imposed upon us. In laying down plans of new sewerage, recourse must not be had to this expedient, nor to the still worse plan of removing by hand labour the accumulations which can only occur in a badly devised system. We do not hesitate to say that no such means and appliances are needed if the sewers are constructed on a practical and efficient plan; and we hold that no sewer discharges its functions aright if it allow the matters committed to it to remain in a stagnant state. We maintain that a sewer is a duct to be employed in passing liquid or semi-liquid matter from a point at which it is received to another at which it is discharged; and that if it fail to do this, and through the sluggishness of its current allow the solid matters held in suspension to settle and

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accumulate, it becomes a cesspool of an aggravated form, and the gullies and house drains are made the instruments of disseminating the poisonous effluvia which it engenders."

With reference to the *utilisation* of town sewage we read:

"Of the processes in actual operation for the accomplishment of this purpose, we are disposed to regard that at Leicester (Wicksteed's) as the most successful. There the sewage on arrival at the outlet is mixed with lime, the solid matters precipitated, and the supernatant water, which from actual inspection we can pronounce inodorous, is allowed to flow into the river. The operation is carried on without creating a nuisance, nor have we heard of any well-founded complaint that the deodorised liquid re-assumes any of the offensive features it contained previous to treatment.

The failure in this instance is the utter worthlessness of the residuary matter. The deodorising agent, the lime, would seem to fail in conserving the fertilizing properties of the sewage, and the residuum becomes in consequence worse than useless, for the agriculturalists in the neighbourhood having discovered that it is of no practical value, decline to accept it even when offered to them gratis.

Having regard to the disadvantages and imperfections of the system of irrigation by means of liquid sewage, and believing that these objections cannot be satisfactorily overcome, we incline to the opinion that the utilization of the sewage of a town will be best effected, as far as the non-production of nuisance is concerned, by the process of precipitation at the outlet, and it remains for our chemists to discover the means whereby this great desideratum may be most effectually and profitably accomplished"

We can recommend this valuable little treatise to all interested in the subject, more especially members of vestries, district boards of works, and boards of health, by whom it cannot be perused without advantage; and we think the thanks of such are due to the author, for publishing in so available a form the fruits of his experience.

COLONIAL PATENT LAW.

By F. W. Campin, F.S.A.

With respect to two matters of the very first importance to the national greatness—the improvement of our manufactures and the colonial system—we are unfortunately not in a position to congratulate ourselves. Regarding the first, we have a very defective patent law, and as to the second, most injurious colonial arrangements; for whilst our colonial system gives ample scope for unnecessary and irritating interference on the part of the home government, it is signally wanting in arrangements for maintaining any federal unity in points of importance to the mother country and to her colonies, so much so indeed, that Her Majesty's minister for colonial affairs would appear to feel himself precluded from initiating changes for the mutual benefit of both, though involving only trifling modifications of existing regulations; and thus, to speak of matters connected with the subject now under consideration, the British government, although repeatedly appealed to, have not procured the initiation of any common system of patent law applicable to the colonies (although it did once attempt to solve the more difficult question of an *international* patent law); and further, has refused to facilitate when needful the recognition of the inventor's rights in the colonies, by receiving the necessary documents at the colonial department and forwarding them to the proper authorities in the colonies. At the same time the British government has sanctioned and assented to such laws as that of Canada, which denies patent rights to a British subject, except he be a legally settled inhabitant of Canada, and makes a patentee subject to fine and imprisonment for not putting his mark upon the patented articles.

With the view of aiding the progress of amendment, the following brief summary of the colonial patent law has been compiled, principally from the official report issued by the Colonial Office. British North America claims first attention, prominent amongst the several provinces of which is

Canada.—The patent law in Canada is dependent on the Canadian statutes of 30th May 1849, and 30th August 1851, which enact that "any person, a subject of Her Majesty and resident in this province, may make application for and obtain a Canadian patent available to him, his heirs, lawful representatives and assigns, for any invention or discovery of any new and useful art, machine, manufacture, or composition of matter," &c., or "any new and useful improvement on any art, machine, manufacture, or composition of matter," &c., or the principle thereof. (2) When actions for damages for infringement of rights granted by patent are brought, the court may grant treble costs; and it is provided that a patent shall not be void although the discovery was known in a foreign country, if it has not been patented or described in a printed publication. Although the plaintiff may happen to fail in his action from a bad specification, the court may adjudge and award as to costs as may appear just and equitable, if the defendant be proved to have violated any part of the invention duly specified and claimed. (3) In case of the inventor's decease before a patent is applied for and obtained, then his legal representatives may apply for and obtain the same. (4) When there are interfering applications for patents, the course to be pursued is to be settled by official arbiters; and parties having taken a patent in a foreign country not to be precluded from having a Canadian patent if applied for within six months. (5) Patents to be assignable in law as to the whole or any undivided part of the interest therein, by written document recorded in the office of the provincial secretary within two months from the execution thereof; and the right to take out a patent may be assigned before the grant of patent, whereupon the patent may be granted to the assignee. (7) To correct bonâ fide errors in the specification and drawings, upon surrender of the defective patent a new one may be issued together with the corrected description and specification thereof, "such new patent to have the same effect and operation in law on the trial of all actions thereafter commenced, for causes subsequently accruing, as if the same had been originally filed in such corrected form before the issuing of the original patent. (8) When the patentee has made his specification of claim too broad he may enter a disclaimer in order to remedy the defect thereby created. This disclaimer not to effect pending actions except so far as may relate to the question of unreasonable neglect or delay in filing the same. (9) Additions to existing patents may be made, subject to revision like original applications; (10) and patents surrendered for correction to be dealt with in the same manner as original applications, and additional and corrected models and drawings are then to be furnished. (11) Extensions may be granted, the applications for same to be decided upon by a board, which board may grant an extension for seven years if upon a hearing of the matter it shall appear to the board, having due regard to the public interest therein, that the patent should be extended by reason of the patentee, without fault on his part, having failed to obtain from his invention a reasonable remuneration for the time, ingenuity, and expense bestowed thereon, and the introduction thereof into use. (12) Notwithstanding the grant of patent, persons who have purchased, constructed, invented, or discovered machines, &c. prior to the application for a patent by another person claiming to be the inventor, are entitled to use such machines, &c. without liability to patentee, but the patent will not be thereby invalidated except on proof of abandonment of such invention to the public, or that such purchase, sale, or prior use has been or existed for more than one year prior to such application for a patent. (13) Patents for designs and works of art may be granted for seven years, &c. (15) Persons counterfeiting the name of the patentee may be subject to fine, imprisonment or both. (16) Patentees to stamp or mark the date of patent on the patented articles, and if they neglect so to do to "be deemed to have committed a misdemeanour, aad be liable therefore to the same penalties as are provided in the next preceding section." (17) Letters patent which may be found invalid may be repealed by *scire facias*; but no scire facias to issue after two years from date of patent or in the term or session of the court next after the said two years. (18) Patents to extend throughout all Canada. (19) The free importation &c. of articles invented in the United States or the British dominions not to be prevented by any Canadian patent. Examinations to be made by the law officers of the crown of the letters patent proposed to be granted. As to inventions being improvements on patented inventions the second inventor shall not be at liberty to make use or vend the original invention, but the improvement only, nor shall the first inventor be at liberty to use the improvement. The inventor to make a solemn declaration that he believes himself to be the true inventor, and to file a specification, drawings &c., and a model may be required if deemed necessary. Provided that any patent be void for fraud or wilful misdescription in specification, and then the patent shall be declared void. Fees to be paid for patent, £5—for copies, exemplifications, drawings, &c. Inventions brought from foreign countries by travellers may be patented, such traveller patentee to make a solemn declaration that he believes himself to be the first introducer.

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New Brunswick.—Patents are granted in this colony upon petition to the governor, accompanied by a written description, with drawings, models, or specimens if need be. The description must be signed by the applicant and attested by two witnesses. A British patentee should supply a copy of his British patent; and the law allows the assignee of a British patentee to take the grant of letters patent. Official charges to British patentees, £8 17*s.* 6*d.*; foreigners, £13 10*s.*, currency. An assignee has to pay 10*s.* additional.

Nova Scotia.—Patents for fourteen years are granted to legally settled inhabitants of the British North American Provinces on application to the governor, when oath is required to be made that the party applying believes himself to be the first and true inventor in the province or colony. Specification in full, accompanied by drawings and models if need be, required on application. The oath or affidavit required may be sworn by the person making such application before any judge of the province or colony in which such person resides.

Prince Edward Island.—Patents are granted here to any person or persons who shall be an inhabitant or inhabitants of this island, or have resided therein for one year previously to making application for the patent. But British patentees have obtained private acts of the legislature to enable them to hold a patent grant. The British patentee seeking to extend his patent right to this colony should therefore in the first instance obtain an enabling act of the legislature, and having done so, and been thus placed on the same footing as a resident, proceed to comply with the requirements of the ordinary law, and petition the lieutenant-governor for a patent, accompanying the same by his affidavit stating that he is the true inventor, and also by a full description of the invention, annexing drawings and written references where the nature of the case will admit, or specimens of ingredients and of the composition of matter sufficient in quantity for the purpose of experiment when the invention is a composition of matter, must accompany the petition, to be filed therewith in the government secretary's office. The only official fee required to be paid is for the public seal to the letters patent, 7*s.* 9*d.* sterling. The fees chargeable on the passage of a bill through the legislature vary in each case, they would be very trifling, and probably not exceed £2 sterling.

Newfoundland.—In this colony the governor in council can grant letters patent for new and useful inventions to any person whomsoever who shall allege he is the true and first inventor. The improver of a patented invention may have a patent for his improvement; but the improver is not entitled to use the original patent, nor the original patentee to use the improvements without license; and "simply changing the form or the proportions of any machine or composition of matter in any degree, shall not be deemed a discovery or improvement." Oath or affirmation must be made by the applicant for a patent that he believes himself to be the true and first inventor. Specification with full description of invention, and model with drawings thereof, to be filed with petition and to be attested by two witnesses. Assignments of patent rights must be duly recorded. Specimens of ingredients to be deposited if necessary. In cases of infringement the patentee may claim treble damages and costs, and the defendant in cases of infringement may plead the general issue. The applicant for a patent not to be debarred his right to a patent in this colony by reason of obtaining a patent elsewhere, provided that such invention shall not have been introduced into public and common use in this colony prior to the application for a patent therein, and that the grant shall not continue in force after the expiration of any patent granted elsewhere. The assignee of an inventor who obtains letters patent elsewhere may obtain a patent. Patents not brought into operation within two years to be forfeited. Notice of intention to apply for patents to be published in the royal gazette prior to such application. Where the patentee claims by his patent larger interest than his invention entitles him to, he will be enabled to maintain his action against an infringer, but will lose his costs unless he has entered a disclaimer, which he may do even *pendente lite*, where his specification is too broad. Where patent invalid by reason of a defective specification the patent may be surrendered, a correct specification filed, and another patent granted with correct specification, &c. Original patentee may have any improvement he may make on his invention added to the original patent. Every patentee to pay fees of office and £5.

Bermuda is stated in the official report to have no laws or regulations as to patents.

NOTES OF THE MONTH.

The Architectural Exhibition.—The tenth exhibition will be opened to the public on the 11th of April next, and will remain open till the 30th June. All drawings and models must be delivered on the 20th inst. It is suggested that the description sent with each drawing should contain an account of materials, cost after completion, object, &c. of the building or design. Plans and sections intended only to illustrate arrangements, should be drawn to a small scale. Inattention to these points, it is mentioned, will in many cases cause plans and sections to be left unhung. There will be a department for models, carvings, decorations, specimens of manufactures, and inventions connected with building, as heretofore.

The Society of Arts.—The Twelfth Annual Exhibition of Recent Inventions will be opened at the Society's house, Adelphi, on the 9th of April. The days for receiving articles are the 22nd, 23rd, and 24th inst.

The Art-Union.—A premium of seventy guineas is offered by the Art-Union for a group or statuette from English history; thirty guineas to the second best model. Also a premium of one hundred guineas for a series of designs in outline to the "Idylls of the King,"—simplicity of composition and expression, severe beauty of form, and pure correct drawing is insisted on for these designs.

Inauguration of the Stephenson Memorial.—The school and institute buildings on the site of the cottage at Willington-quay, where George Stephenson resided, and where his son Robert was born, has been inaugurated. The building occupies about a quarter of an acre. It is from the designs of Mr. A. Dunn, architect. It embraces three separate school-houses: a boys' school capable of containing 150; a girls' and an infant school, each adapted for about 100 children. A dwelling for the master and mistress is attached, besides a reading-room for the inhabitants of the neighbourhood. The style is Gothic, and is of brick, with stone facings.

The Institute of British Architects.—The institute has awarded the gold medal to Mr. Sydney Smirke; and a medal of merit to Mr. G. E. Street, for his essay on Mediæval woodwork, illustrated with pen-and-ink sketches.

Falmouth Docks.—Messrs. W. and J. Freeman have received the acceptance of their tender to supply the granite for the construction of these works. The half-yearly meeting of the docks company was appointed to be held on the 28th ult. Lord Falmouth accepted the invitation of the directors to lay the foundation-stone of the breakwater on that day.

International Exhibition of 1862.—At the council meeting of the Society of Arts on the 23rd ult., the guarantee deed for raising £250,000 for the Exhibition of 1862 was approved.

The Continental Hotel, Pennsylvania.—This great hotel will shortly be opened for the reception of inmates. It is the great tavern of Philadelphia. The furniture is now going into some of the rooms, while others are receiving the finishing touches. It contains 530 rooms, so distributed and arranged that every one is fully supplied with light. Every possible convenience of modern architecture has been introduced in boundless profusion. Of the chambers, 300 are supplied with hot and cold water, and there are 50 bath-rooms similarly furnished with water: there are 50 water-closets on the different floors. A tank on the roof contains 50,000 gallons of water, from which pipes lead off for the supply of hose in case of fire. The water tax for the building has been fixed at 1000 dollars the first year, and a meter will be used to ascertain the annual consumption. A steam engine will be constantly at work in the basement, and will operate a sort of passenger railway or dumb-waiter, for conveying boarders from the ground-floor to the upper stories without the labour of walking up stairs. Another similar contrivance has been provided for the hoisting and lowering of baggage. The Continental is probably the largest and most costly hotel in the United States.

Competition.—Carmarthen Town-hall.—Plans are invited for altering and improving the present shire-hall, Carmarthen, with a view to render it more commodious for the holding of assizes and quarter sessions. A ground plan of the present town-hall and the county premises adjoining may be seen at the office of the clerk of the peace, at Carmarthen. Plans are to be sent to the clerk of the peace by the 27th inst.

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NEW CORN EXCHANGE CHAMBERS, SEETHING LANE, LONDON.

(With an Engraving.)

THIS building is erected at the back or eastward of the old Corn Exchange, Mark-lane; and is built for the purpose of obtaining a subscription room and offices in connection with the exchange, of which it will form a part. The proprietors of the old Corn Exchange in their corporate capacity, not having power to erect such a building, the want of which has been long felt, it has been undertaken by some members of the Corn Exchange who have formed themselves into a company for the purpose, limiting the distribution of their shares to shareholders of the old Corn Exchange.

The building is situate on the west side of Seething-lane, on which it has a frontage of about 85 feet. It contains on the ground-floor a lofty subscription room 56 feet by 38 feet: a refreshment-room, retiring-rooms, a board-room 30 feet by 17 feet, secretary's room for the use of the Corn Exchange, and a spacious corridor, with entrance by a flight of steps from Seething-lane. In the basement is a commodious kitchen with offices in connection, and vaults communicating with the vaults under the old Corn Exchange. On the floor above the ground-floor are several convenient and light offices approached by a stone staircase and fireproof corridor and landings. On the upper floor are the rooms for the resident attendants. The elevation is in the Italian style of architecture. The lower portion of the building, the cornices, and the dressings to all the windows are of Portland stone, and the wall spaces are of red brick pointed with black mortar. The whole of the internal fittings are to be of wainscot.

The amount of the contract for the building is £13,000. Messrs. Piper and Sons, of Bishopsgate-street, are the contractors; Mr. Acomb, clerk of the works. The carving of the stonework has been principally executed by Mr. Earp, of Lambeth. The wrought-iron gate at the entrance is by Mr. Marriott. The work was commenced in February 1859, and is now rapidly approaching completion. The whole is being executed from the designs and under the superintendence of Mr. Edward I'Anson, F.I.B.A., of Lawrence-Pountney-lane, London.

ON THE PRESENT POSITION OF ARCHITECTURE IN THIS COUNTRY.

THE object of this paper is not to compare the present position of architecture or the condition of the building trade with the past, or to enunciate and attempt to prove any theories respecting the one or the other, but simply to refer to a few matters of actual fact easily cognizable at the present day, and which, if looked at simply as facts, may serve partially to depict the present position of architectural affairs. Such a paper unfortunately is not very often written, perhaps because the general tendency of most men's minds is to take it for granted that they remember and give full weight to all circumstances that have passed within the scope of their own experience, so that when information is sought it is chiefly about the past, while contemporary occurrences and events are considered more as topics for speculation than for history.

This is undoubtedly natural, but it is nevertheless desirable to remind ourselves from time to time of what is actually going on around us, and to put on record abstracts of the events of the day. Such observations must almost of necessity be fragmentary and disconnected, and it is feared that in the present instance they will be found also incomplete; still it is hoped enough will appear to have been collected to enable all those for whom these matters have any personal interest to draw their own comparisons between the past and the present, and to deduce their own prognostications of the future.

Nothing is more striking or more prominent in the aspect of the present day than the great scale on which building works are now undertaken, and the evident conviction that has taken hold of the public mind, that a new building ought to form a part of almost every public or private undertaking of any importance. Most public companies, municipal, charitable, and parochial bodies of the present day require a building to be erected for them, often one of great magnitude. The new poor law was passed within no very distant period: one of its results has been a series of vast public buildings that might be enumerated by hundreds. Since then public attention has been directed to the amelioration of prisons, and a new series of buildings of extensive size and wonderfully precise arrangement has followed the efforts of Colonel Jebb and his friends. Again, the subjects of lunacy and idiocy, the reformation of juvenile offenders, the dwellings of the poor in cities, and the wants of the sick, destitute, and helpless, having one after another attracted public notice, we have had a series of magnificent county lunatic asylums, of which that at Colney-Hatch is perhaps the best known, several idiot asylums, reformatory and industrial schools, model lodging-houses and dwelling-houses, and institutions and asylums of various descriptions. Among the most recent of these we may refer to the large asylum at Hayward's Heath, the Middlesex Industrial Schools at Feltham, by Messrs. Banks and Barry, and the new and very successful dwellings for families now erecting for Miss Burdett Coutts by Mr. Darbishire.

Railways have given rise to a most extensive and frequently costly series of structures for the purposes of stations and warehouses, and have been the occasion of the erection of numerous hotels, usually of large size. In another direction it is remarkable how essential it now seems to be thought for the success of a new public company of any pretensions that, even at the risk of locking up capital which ought to be disposable for commercial purposes, it should be provided with a costly building erected for itself. Among the many recent erections of this class are, the picturesque building for the office in London of the Electric Telegraph Company, by Mr. Horace Jones; the noble building in Liverpool of the Liverpool and London Insurance Company, by Prof. Cockerell; and the offices in Edinburgh of the Life Association of Scotland, by Mr. Rhind. The same disposition to spend money freely and on buildings of large size is shown in the edifices for commercial purposes recently erected in many of our great cities. From some cause London is in this respect unquestionably far behind several of our provincial towns. There are it is true in the metropolis new warehouse buildings in abundance, but too generally designed with a timidity, a spirit of common-place, and a poverty of invention which are not found in the works at Manchester of Mr. Walters, those at Nottingham of Mr. Hine, those in Glasgow of Mr. Billings, and many others to which we could refer.

Connected with this extensive demand for new buildings there has been a great increase in the number of architects, of master builders, and building operatives, and a new and more complete organisation of the building trade. This accession of numbers has given rise among architects to an almost universal system of competition; and to combination as well as competition among the master builders and the workmen.

Architectural competitions will be admitted by most who know the state of the profession to rank as the least satisfactory part of our present system, not so much because of defects in the theory of the thing, as because practically the committees and judges who have the conduct of competitions are entirely destitute of the proper qualifications for the position in which this system places them. There have not been any very recent competitions of such great general interest as those for the Government Offices, and for the Memorial Church at Constantinople, but there have been within the last twelve months a great number of competitions of more moderate dimensions. The most important undoubtedly was that for the Manchester Assize Courts; the most novel both for subject and for mode of selection that for Mr. Spurgeon's Tabernacle; and among the most recent those for the Cambridge Guildhall and for the Hartley Institution at Southampton. Some of the competitions of the year have shown an advance in the direction in which it is highly to be wished an advance should be made, namely, in the appointment of professional men as judges, or assessors along with the committee. Even however in the case where the greatest precaution was taken to obviate all ground for suspicion of unfairness (we refer to the Jews' Hospital competition), the dissatisfaction which unsuccessful competitors naturally enough feel at the decision, found vent in no very gentle insinuations and remonstrances, so much so as to lead to the doubt whether it will ever be found possible to arrive at a mode of deciding competitions that will prove satisfactory to all.

Several competitions on the continent have attracted the attention of English architects. No prize was awarded to an English competitor in the contest for the Prisons at Turin and Genoa, but it will not be forgotten that the design of Messrs. Jones and Barber, precluded from receiving a prize owing to some informality (we believe the absence of a detailed estimate), was

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mentioned by the government authorities in a way which was almost more gratifying than the obtaining the first prize would have been, and that the government entered into treaty with the architects to purchase it. The English competitors for the Theatre at Rio Janeiro have been more fortunate; and we cannot but regard it as a significant mark of the ability of our architects that seldom a year passes without some prize of value in competitions open to all the world being carried off by an English architect.

In leaving this subject we ought perhaps to recall the decision upon the designs for Mr. Spurgeon's Tabernacle. In that instance the system of allowing competitors to become their own judges was followed, and it was felt that the result was very unsatisfactory. It is however worth remark that in one respect this decision was more in accordance with the instructions than the verdict of a non-professional committee often is, we allude to the question of cost. Most of the designs selected appear to have been such as could have been executed for the amount stipulated, and as some of the rejected designs were undoubtedly too elaborate to have been brought within the amount, we may hope that it was a concientious feeling that led to the rejection of several sets of plans decidedly superior in artistic merit to either of those chosen. Still if this is the only advantage to be gained by making competitors their own judges it is one that could be better secured by the employment of an experienced surveyor to report upon the cost of designs submitted.

The subject of competition drawings leads on naturally to other drawings and to photographs, and the exhibitions at which they appear. We have now several regular annual displays, namely, that at the Architectural Exhibition, the Royal Academy, the Architectural Photographic,—and the Photographic Exhibitions, and the Exhibition of Building Materials. The oldest of these, namely, the architectural room at the Royal Academy, has long been open, and will probably always command a fair proportion of the best architectural drawings exhibited in each year; but the more important collection is undoubtedly that of the Architectural Exhibition. That such an exhibition should be founded at all, and being founded should prosper and advance, is a cheering fact. The exhibition of last year (1859) was looked forward to with a good deal of interest as being the first held in the new gallery, but it hardly realised the expectations formed of it, and was far from fairly representing the building progress of the year. It is earnestly to be hoped that the profession as a body will see the desirableness of making the Architectural Exhibition—and, if they will, the room in the Royal Academy—a matter of more serious attention than last year. Drawings or photographs of executed buildings are wanted in order to make the exhibition a real index of what is being done; and in cases where there is no opportunity of anything else, the actual working drawing of a recently erected building would be often a more valuable, as well as a more inexpensive contribution to the Architectural Exhibition, than the best perspective that could be made of it before it is commenced.

The free exhibition of building materials is an interesting and useful one; and it usually contains an extensive collection of manufactured articles, and of materials likely to prove serviceable. In the existence of such an exhibition, and the variety and excellence of the articles exhibited, we have one of the best proofs of the activity of the building trades and of the large amount of high-class work now required.

The three annual exhibitions of the Architectural Photographic Society have all been interesting, though open to the exception that the photographs were not sufficiently special in their character fairly to carry out the object intended to be accomplished. The society itself has recently presented the anomalous appearance of having been brought to the verge of extinction by nothing in the world but its own prosperity, and was all but relinquished, solely because its business had become too large for any honorary officers to manage, while its nature renders it of course impracticable to turn the society into a mere trading speculation. We heartily wish it well under its new form; and yet we fear it may prove after all that a trading company would be more able to work the undertaking with advantage. For the warning of the new managers it may be right to point out that the ruinous prosperity of the late committee was entirely due to their stepping out of their proper walk. Had they made it a rule to exhibit and sell nothing at all but views of architectural objects, so strictly special in their adaptation to the purposes of the architect that many of them would be almost unsaleable in ordinary shops, they would have had fewer subscribers, but enough for their purpose, they would have done far more good, they would have established a far greater claim on the good-will and support of the profession; and lastly they would have escaped the reproach, not undeservedly brought against them, of injuring the trade of the dealers in photographic views. The Architectural Publication Society pursue the wiser course of publishing what every architect will wish to possess but no one save an architect will ever care to have; and we are glad to be able to record its increasing prosperity.

All the societies in London connected with architecture are at the present moment peculiarly indebted to the Architectural Union Company for the aid it has given them in their efforts to make progress; and we can hardly doubt but that, as this company is but the natural result of the gradual advance made by the profession generally, so it in its turn will prove to be one of the most beneficial agents at work in the movement unquestionably going on. The premises in Conduit-street, which this company was formed to secure and adapt to public purposes, have been remodelled, and afford admirable accommodation for the Institute, the Association, the Architectural, Photographic, and Building-materials Exhibitions, the Publication Society, and the Union Company itself, and form a meeting point for the members of the profession. Already this step has suggested the idea of an Architects' Club, an idea which sooner or later will no doubt be put into execution. All the societies in coming into their new premises seem to have been stirred up to improvement and increased energy, while the premises themselves are such as will attract members to attend by their convenience and good situation. In the Institute especially, the formation and liberal support of the portrait fund and the removal fund, and the very large number of new Associates and Fellows (the list proposed at the opening meeting of the present session being the largest ever yet brought forward), all show the wish that is felt to keep up the efficiency of the society.

The Architectural Association has also a claim to be noticed; it has now existed for a considerable length of time, and many of the papers read before it are of a high order of merit, while its rules and constitution, and above all the spirit in which it has been and is carried on, render it peculiarly adapted to be of service to the younger members of the profession.

In leaving the subject of architectural societies we ought to mention that several such now exist in various parts of the country, as Oxford, Liverpool, and Glasgow, besides numerous archæological societies.

The gradual prevalence of the social principle of the division of labour, combined with the great amount of work done in the present day, has raised up a new class of men to undertake it. General contractors are almost the product of the present generation. We find among them the same prevalence of competition as among architects; but although this is a keener and more unscrupulous description of competition, it would not be difficult to show that the evils attendant upon it are comparatively slight, a fact due no doubt to the circumstance that competitions among contractors are controlled and decided by professional men, conversant both with the nature of the work to be done and with the methods necessary to follow in order to insure that all shall be placed on an equal footing and impartially dealt with.

The situation of the builders has however been long one of latent hostility towards concealed enemies among their own workmen: this has at length been brought to a head in the well-known Nine Hours movement, and the unhappy Strike, now at last terminated. During the whole of the early part of 1859 this movement, the aim of which was that the workmen should still receive the daily pay of ten hours' work, but only labour for nine, was abundantly ventilated at numberless meetings of the operatives; and at length, matters being deemed ripe, and a very busy period of the year having arrived, which would render such an attempt more formidable than at other times, an effort was made to gain the nine hours day by a strike, commencing with a single firm, that of Messrs. Trollope. This occurred at the end of July, and on the 6th of August nearly the whole of the masters in London closed their shops entirely, with the intimation that those who returned to work would have, in one form or another, to give their assent to a declaration to the effect that they did not and would not belong to any society that interfered with the hours or terms of labour, and recognising the right of employers and employed to settle these in each instance as they chose. It was also announced that no shop would reopen until that of Messrs. Trollope was again filled. In rather more than a month, that

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firm reported that they found themselves in a position to resume their works, and on the 12th of September the employers opened their shops, though in many instances it was but a mere handful of men who returned at first to their work. During this month several establishments gave way, and reopened unconditionally, but a compact body of masters, and those the employers of by far the greatest number of men, retained the declaration, and their shops have more or less rapidly resumed work.

Meanwhile, on the side of the men the greatest activity was displayed in collecting funds, and considerable skill shown in their distribution. In the earliest stage of the struggle, its promoters, abandoning the nine hours question, which proved eminently unpopular as a ground of strike, adroitly turned the attention of the men to the "document" as the principal object of their resistance, and succeeded in maintaining an obstinate and determined opposition to it. The opinions of one or two legal persons of note were brought forward against it, although its legality seems to have been established by the letter of Lord St. Leonards. That the declaration has caused a large amount of dissatisfaction and evoked resistance is not necessarily a proof that it was wrong. It may have been an error in judgment, but as embodying the views of the masters it seems as distinct as anything could well be.

The report of the Registrar-General (republished in the *Times* of March 15, 1860) showed that the loss of life attendant upon that conflict had been considerable. The misery and want entailed by it cannot be imagined, and must continue to be felt even now the struggle is at an end.

The masters having gained their point have now withdrawn the declaration, substituting for it Lord St. Leonards' abstract of the state of the law as it bears upon the relations of employer and workmen; and the committee of workmen have now ceased to pay the sums which have during the continuance of the contest been each week distributed among the artizans and labourers who were standing out.

It is not proposed, for it would not fall in with the intention of this paper, to give an opinion on this very difficult question in an absolute and dogmatic way, but there are one or two remarkable features of this strike which may be interesting to point out. Nothing is more creditable to our advanced state of order than the marked absence of violence and ill conduct such as have accompanied other strikes; very few cases indeed arising directly or indirectly out of it having been brought before any of our tribunals. The efforts made at conciliation by the Society of Builders' Foremen, the Anti-Strike Society, the Kettering Operative, the Masons' Society, and others, are all interesting and praiseworthy; and these two things denote a greatly improved state of public feeling among workmen. The whole occurrence points to the safeguards needful in making great social changes. The gradual massing together of trade into the hands of employers of great wealth and capital has altered very much the relation between master and man, and it would not be difficult to show that the strike has arisen mainly from the fact that this alteration has not been enough recognised, or properly provided for as it went on.

On turning from these, which may be termed the social aspects of architecture, to her actual achievements, and the character of the works executed lately and at present in hand, the most conspicuous characteristic of the day is undoubtedly the revival of Gothic architecture, the rapid progress which has been made by the professors of this school, and the importation into English works of a great deal of the feeling and the detail of various styles of Continental Gothic.

Of course, in the new churches so numerous and so excellent the Gothic of the day is most unmistakeably exhibited, and among them perhaps the best type to select is Mr. Butterfield's church in Margaret-street. This church has been followed, or at least the peculiarities of its architecture have been adopted, in many respects for many other churches. The use of red brick, the foreign and unconventional tracery and detail, the polychromic decorations, and other peculiarities, are now extensively to be found in churches, though nowhere so prominently as here. To attempt to give a list and description of the many churches, and chapels that have been lately erected, even of those completed during one year, would be here impossible. A very large proportion will be found to possess more unusual features, and more freedom in the treatment of general design and of detail, than a few years ago would have been held admissable. Probably however, the most successful of all is a work for few portions of which the architect has travelled further than France, while almost the whole is thoroughly English,—we allude to Mr. Scott's exquisite chapel at Exeter College, Oxford. In the same city there is also advancing towards completion the most conspicuous and remarkable of the Gothic secular buildings of the day—the Museum. This structure is deserving of special attention, as being in many respects more truly modern in its architecture than anything else yet produced. The style of Mr. Scott's design for the Foreign Offices, and of the striking design for the proposed Parliament House at Ottawa, each exhibit some of the peculiarities markedly distinguishing the Oxford Museum; and we recommend this work to the careful study of all those who, belonging to the New Gothic School, are anxious to see combined both the greatest beauties and the peculiar weaknesses of their style.

England was early in the revival now more or less prevalent throughout Europe, and although many of the modernists affect to despise the Houses of Parliament, it is beyond question, that not only has that magnificent building done more than any other one cause to further this movement, but also that in this palace England possesses the grandest pile that Gothic architecture has raised for secular purposes in this or any preceding age. The progress of this our greatest national building has been marked chiefly by the gradual rising of the roof on the Victoria Tower, and the repeated mischances of the Great Bell,—mischances which compel us to regret the appointment of the distinguished amateur under whose management they have occurred.

This building can now be better seen from the river, owing to the opening up of the approaches to New Westminster Bridge, and the partial completion of the bridge itself. Both the foundations and the superstructure of this great work show a highly advanced position of engineering skill, but it is sincerely to be deplored that the talented engineer who designed this bridge has committed the same error which has been so damaging to the effect of his Chelsea Bridge,—namely, trusting to either his own taste or the taste of some other person more acquainted with engineering than with architecture, for the details and ornamentation. At Westminster especially these points should have been under the control of either Sir Charles Barry, or some other architect of experience and skill. Probably the most appropriate treatment would have been that which, as in Hungerford or Southwark bridges, displayed the ironwork just in those forms into which it was needful to throw it to make it do its work. It has been however thought proper to add mouldings and spandrils of an architectural character, and these ought unquestionably to have been designed by some one more conversant with architecture than the person who did actually design them.

Two other great bridges have by their near completion claimed attention during the past year, and are associated with the two great men whose deaths have made 1859 a year of sorrow to the world of practical science:—Brunel's Saltash Bridge, and Stephenson's Victoria Bridge. Each of these structures is a masterpiece in its way, and their character, as different from one another as any two structures can be, harmonizes well with the very opposite natures of their two great authors. The two bridges can be compared at the Crystal Palace, where a model of each is exhibited. The Canadian bridge is the more massive, simple, straightforward—the more easily understood and the more safely to be imitated of the two;—Saltash by far the greater mechanical triumph—a more subtle work in principle, more difficult to carry out, but one of beautifully scientific design.

These notices must now be brought to a close, notwithstanding that such is the activity of the present day, and so great the range of its exertions, they might be almost indefinitely extended; but terminating at this point they must necessarily be very far from complete. The vast extent of speculative building, with all its peculiar features, has not been in any way described. The attempt has not been made to present even an enumeration of the large number of public and private buildings which for their importance and their excellence might well claim notice; nor to discuss two most important elements in the artistic and the structural progress of architecture,—we allude to the prevalent taste for introducing continental features, due to the greatly developed intercourse with the continent; and the new materials which the advance of the arts and the improvements in manufactures are placing at the disposal of the architect. Enough has however been said to show both activity and progress, and so long as our public professional institutions and the works of those who support them exhibit so many signs of vitality, while

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the acquaintance of the general public with architecture continues to increase, and the apathy with which that art was once regarded steadily diminishes, we shall undoubtedly at each review of the past and the present see reasons for deriving hope for the future, and shall be able, as we are this day, to look around upon many things well begun, others well carried on, and not a few worthily accomplished.

TRIANGULAR RING JOINT IN USE ON THE CAMDEN AND AMBOY RAILROAD, U.S.

By J. C. Trautwine, C.E.

This triangular ring-joint has been in successful use for seven or eight years on portions of the Camden and Amboy Railroad between Philadelphia and New York. A recent examination of some of these joints, which have been for about three years traversed daily by from twenty to thirty freight and passenger trains drawn by heavy engines, has fully convinced me of their merits. It is probable that this joint may furnish hints for further improvement, and perhaps lead to something superior to any of the joints and chairs now in use. It was devised by Mr. E. A. Stevens, who was for many years superintendent and is now president of the road.

Fig. 1. Fig. 2.

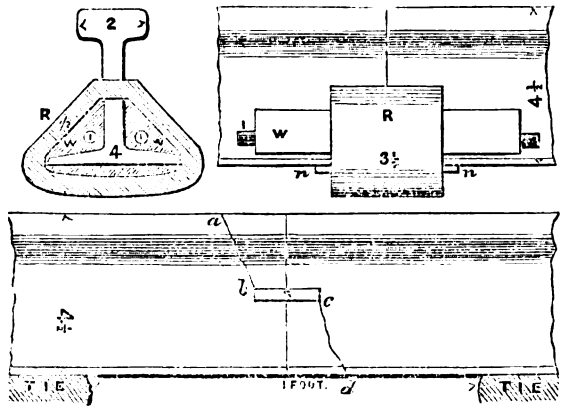


Fig. 3.

The circular ring-joint, which was made on essentially the same general principle, was found liable to the objection of revolving under the action of the trains, and thus greatly expediting the loosening of the wooden wedges by which it was confined to the rail. This difficulty is obviated in the present joint. Its construction is simple, consisting merely of a continuous nearly triangular ring or sleeve R (Figs. 1, 2) of wrought-iron, 3¼ inches wide and ½-inch thick. The top of this ring passes through a slot S, Fig. 3, cut out of the ends of the rails; and after being fixed in its position, two cast-iron wedges W, W (Figs. 1, 2), 7½ inches long, and with a very slight taper, are driven between the sides of the ring and those of the rail. These wedges, being liable to break, are strengthened by rods of wrought-iron I, I, ¾-inch in diameter and 8½ inches long, inserted as a core when the wedges are cast. A thin wedge of plate iron *n*, is also driven under the rail. The joints are placed, not over but between the cross-ties; the distance apart of which is there diminished to about one foot in the clear (Fig. 3).

This is the simplest and cheapest joint that I have seen. The ring-joint on that portion of the road which I have examined carefully has for about three years sustained the traffic of about twenty-five trains daily, drawn by heavy engines, yet the joints are in perfect condition, and the ends of the rails so free from bruises and splits, that I at first thought they had been laid but a few days. The weight of the rails is about 65 lb. to a yard; and I observed that where the same rail had been laid for the same length of time and had endured the same traffic, but with very heavy cast-iron joint chairs resting on the cross-ties (instead of the ring-joint), the ends of the rails were bruised and the joints comparatively uneven.

In close proximity to the foregoing and under the same general circumstances, is the 91 lb. rolled rail, with strong wooden fishing beams at the joints (similar to what is known as Trimble's joint), and also devised by Mr. Stevens about fifteen years since. This rail has worn much more rapidly than the smaller one, and its ends are considerably bruised, while those of the 65 lb. rail laid with the triangular ring-joint are almost as perfect as on the day they were laid, about three years ago.

Again, at the point at which the foregoing observations were made, the Camden and Atlantic Railroad crosses the Camden and Amboy. The rail of the former road is the inverted U, and its joints are connected by an inverted T chair of rolled iron, 5 feet long, with 4¾ inches width of base, the base being ½-inch thick. This chair rests on three cross-ties, the middle one of which supports the ends of the rails. Although the traffic over this chair is very trifling in comparison with that over the ring-joint of the Camden and Amboy road, yet it has sufficed to show that owing to the rigidity of the former the ends of the rails are exposed to more rapid deterioration than with the ring; it is probable however that the difference is partly due to the inferiority of the ∩ rail itself. I am of opinion that the ⊥ joint would prove much more serviceable if the ends of the rails met between two cross-ties, instead of resting upon one. It holds the rails in place extremely well, and certainly possesses much merit, but is very expensive.

The triangular ring-joint is not free from defects. Its wedges loosen and require frequent re-driving, as is always the case where such wedges are used with rail chairs. This however is a consideration of but little importance; and the track men find this joint to require much less attention than chairs with wedges. A more serious one is, that where the foundation on which the cross-ties rest is bad and permits much unequal settlement, the increased strain thereby brought upon the ends of the rails and upon the ring-joints occasions a tendency to split off a portion of the end of the rail either above or below the slot, as shown by the lines *ab* and *cd*, Fig. 3. Very nearly all break below, along *cd*. This can be avoided only by careful attention to maintain the constant adjustment of the track. It has taken place to but a limited extent on the Camden and Amboy road, and fortunately is not attended by any danger to trains. The taking up of a rail and replacing it by another with the ring-joint is an operation of no more than the ordinary labour involved in the process of changing rails. The engines and trains pass over the joint very smoothly, without any perceptible jar or noise. The rings are formed on a mandril of the required shape.

Col. Cook, chief engineer of the Camden and Amboy Railroad, fully concurs with me in considering the triangular ring as being the best of the many joint fastenings and chairs that have been so thoroughly tested on that important work. He is extending its use upon the road as fast as the necessity for laying new rails permits him to do so.

With some simple device for preventing the loosening of the wedges and the breaking of the rails this joint would leave little to be desired. Perhaps the former might be attained by using wrought-iron for the side wedges W, the smaller ends of which might be suddenly tapered off, so as to be readily bent outwards a little after being driven; and the latter by the use of longer and stouter bottom wedges.

[*] From the Journal of the Franklin Institute.

MONUMENT TO THE DUCHESS OF GLOUCESTER, WINDSOR.

Within the last month, a sumptuous monument has been completed and erected in the south aisle of St. George's Chapel, Windsor, immediately at the back of the choir stalls, in memory of the late Duchess of Gloucester. The design, which was entrusted to Mr. G. G. Scott, consists of an oblong altar-tomb, attached to a retable containing four bas-reliefs in square quatrefoil panels, enclosed in a border moulding to the whole, which is so arranged as to harmonize in its leading lines with those of the ancient wooden screen with its curious paintings just behind and above. The tomb has on its front a cusped panel in the centre, containing the shields and supporters of the family arms, and on each side in a sunk brass tablet the names and dates of the various royal personages who lie entombed in the vault beneath. Along the top edge, likewise in brass letters, runs the following inscription:—"This monument has been erected by Queen Victoria, as a tribute of respect and affection to her beloved aunt, Mary, Duchess of Gloucester, A.D. 1859." The front and sides of the tomb are of statuary marble, the plinth and base

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mouldings with the top slab are of serpentine. On the latter is incised a very handsome metal floriated cross. The bas-reliefs referred to are in statuary marble, and illustrate the "acts of mercy," these are surrounded by a series of inlay marbles of the choicest description, variously disposed in triangles, circles, roses, cinque foils, &c. The east and west ends of the monument, as well as the surfaces below the retable not concealed by the tomb, are enriched with small lozenge-shaped diapering, containing in repeated succession the arms of England, Scotland, and Ireland, as heraldic badges; the rose, thistle, and shamrock are also occasionally introduced.

The marble and mosaic work generally has been executed by Mr. J. Birnie Philip, of Vauxhall-bridge-road, who has among others used the following:—Sienna, bardilla, green and red serpentine, Languedoc, and Anglesea green marbles, and lapis lazuli. The sculptures are by Mr. Theed, of Henrietta-street, Cavendish-square; and the metal work is by Skidmore, of Coventry.

NOTES OF SOME ARCHITECTURAL WORKS IN PROGRESS IN THE CITY OF LONDON.

A considerable number of extensive works are now in progress in the city of London, and preparations are being made for the execution of several others. The church of St. Michael, Cornhill, has undergone extensive external embellishment and internal decoration during the last eighteen months, under the joint direction of Mr. G. G. Scott and Mr. Herbert Williams, architects. These improvements of this work of Wren's are now nearly completed. It is however to be hoped that the good work will not cease until the tower of the church, which is of pseudo-Gothic character, has undergone some modification. In all the external moulded and carved work Portland stone has been adopted, which doubtless is the best material for resisting the peculiarly corrosive nature of our climate, impregnated as the London atmosphere is so largely with smoke and deleterious gases. The windows of the church have been filled with a series of subjects in stained glass of a very superb description admirably rendered by Messrs. Clayton and Bell, and the plain commonplace pointed roofs, and the columns and capitals of the nave, aisles and chancel, have been very judiciously and pleasingly partly coloured and partially gilded. The reredos is of moulded alabaster, relieved by coloured marbles, and the whole of the open seats and stalls have been executed in oak by Mr. Rogers, the carver. The pulpit is pentangular in plan, with sunken panels containing emblems of the Evangelists on four of its sides.

Great praise is due to the authorities of St. Michael's in having exerted themselves so strenuously in the embellishment of their church, and it is to be hoped that other parishes in the city will follow so good an example. It is expected that the church will be opened about the first week in May.

St. Sepulchre's Church, Snow-hill.—The square tower at the western end of this church having been found to be in a very dilapidated state, it has been restored with Portland stone, under the direction of Mr. G. G. Scott, architect. Messrs. Lavers and Barraud, the eminent glass stainers, Endell-street, Bloomsbury, have just inserted at its eastern end a magnificent stained-glass window having representations of the Crucifixion and the Entombment, with large figures of the Apostles, admirably executed. The whole of the interior of the church has been renovated in a plain and subdued manner, and it now exhibits a great contrast to its former dingy and sombre appearance. The original church was one of those destroyed in the great fire of London. The present structure is said to have been built from the designs of Wren; this however we doubt very much, as it possesses no claims whatever to architectural excellence. It is to be regretted that Mr. Scott was not instructed by the authorities of the parish to re-case the tower entirely in a better style, and to remove the commonplace-looking entrance porch, substituting for it one of a more appropriate character.

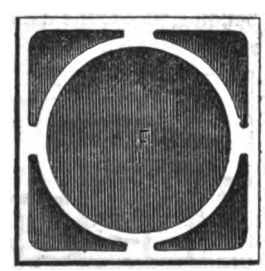
Warehouses, Mincing-lane.—An extensive and interesting structure is drawing to completion, to be used for the warehousing and sale of colonial produce. This structure, which is faced with Portland stone, is from designs by Mr. John Whichcord, architect, and exhibits a free adaptation of Italian characteristics, very effectively embellished with carvings by Mr. James Tolmie, the eminent architectural sculptor. The façade of the edifice presents some peculiarities. The windows are all square-headed, and divided into two lights by moulded mullions. The soffits of the first-floor windows are decorated in their centres by segmental terminations filled with foliage and flowers, projected from the main line of the walls and terminated by representations of eagles. The entrance porch is of the Doric order, and its entablature is surmounted with a group of sculpture in clear relief, produced in a bold and highly characteristic style, reminding one of the productions of Caius Cibber, and the immortal Gibbons. Mr. Lewis Glenton is both the proprietor and builder.

The magnificent *Hall of the Clothworkers' Company*, in Mincing-lane, has been recently completed from the designs of Mr. Samuel Angell, architect. It is a structure rivalling the greatest efforts of the Venetian and Florentine merchant princes.

IMPROVEMENTS IN VENTILATION.

The introduction of an efficient system of ventilation in our dwellings and public buildings, and one easy of general application, is an object of the greatest importance, few of the arrangements at present adopted being at all satisfactory in operation. A new method of ventilation has recently been introduced, the arrangements of which we will describe.

Instead of the usual wood trimmer heretofore fixed in front of chimney openings, a perforated iron one is inserted, having on one of its sides shoes, which receive the ends of the joists. On the other side is a flange which supports hollow corrugated hearth-blocks, that supersede the use of the usual half-brick trimming arches; the openings in the iron trimmers corresponding with those of the hollow hearth-blocks. Similar hollow chambers are continued up the sides of the fireplace, and over each of the chimney openings is constructed a strong air-chamber arch-block, having a conical flue through its centre. The smoke flues are all circular, 7½ inches in diameter, and are formed within a square chamber, as shown in the annexed diagram. These commence on the arch block, and extend up to about 2 feet above the roof of the building in which they may be fixed.



In the external walls ornamental perforated air-bricks are fixed, of any sizes corresponding with the courses of ordinary bricks. These admit the external fresh air which passes to and through the trellised iron trimmer and hearth-block up the sides of the fireplace, through the arch-block, and ascends the air-chambers that surround the smoke flue up to 8 feet from the floor line. At this point the air is diverted at right angles to each side of the apartment required to be warmed and ventilated, through hollow blocks, which are made to bond in with and form part of the brickwork of the building. Internally openings are formed in the ceiling and the upper portions of the walls, which communicate with the air-chambers round the flue, and through these apertures the hot vitiated air is drawn off. Above the roof a stringcourse of perforated glazed brick is formed, which allows egress for the impure air.

One of the earliest applications of this system is to be seen in some offices recently erected in connection with the cadets' military academy, Woolwich. We recently took an opportunity of examining the arrangements as carried out there. A sheet of paper was tacked over the openings before-mentioned, which paper was kept fluttering nearly at right angles from the walls by the volume of warm air entering the room by the opening near the ceiling. The extracting chambers were charged with shavings, from which, on being ignited, smoke and flame issued through the side openings, which was drawn off by the extraction chambers surrounding the smoke-flue.

The results already obtained appear very satisfactory, and we shall watch with interest the success attending the application of this system of warming and ventilating to other buildings. It has the great advantage of being very simple and very inexpensive. The inventor and patentee is Mr. G. Jennings, the sanitary engineer, of Blackfriars, London, who we understand has been recently commissioned to apply his system to the new Royal Marine Infirmary, Woolwich; and to the Royal Victoria Hospital at Netley.

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ON A NEW METHOD OF SHORING.*

By William Anderson.

It being found necessary last year to construct a more extensive cash office in connection with the Royal Bank, Dublin, to meet the requirements of their increasing business, several architects were invited to suggest as to the best means of accomplishing the object, and finally the plan proposed by Mr. Charles Geoghegan, of Great Brunswick-street, Dublin, was adopted.

Mr. Geoghegan's proposition was to purchase the houses at the rear of the bank, facing Anglesea-street, and construct one large and lofty room, stretching from it to Foster-place, by covering in the court-yard between the two houses, and removing the ground and first floor walls of the building in Foster-place.

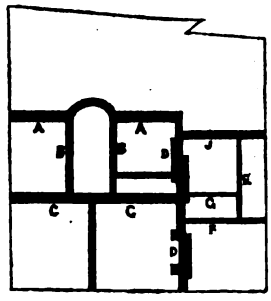
The directors perceived that this plan, though bold, and to a certain extent hazardous, was eminently calculated to afford the additional accommodation required, without interfering very materially with the business of the bank, because neither the front in Foster-place would be disturbed, nor the basement and three upper floors rendered uninhabitable during the execution of the works.

Still there were some misgivings as to the wisdom of attempting to remove the lower portions of eight walls, to do which it would be necessary to support upwards of 200 tons at an elevation of 40 feet above the basement story; and the author believes Mr. Geoghegan himself would have been slow to propose it, had not a novel and safe means of accomplishing his object presented itself to his mind.

Exclusive of the danger and unsightliness of settlements, almost sure to result if it were attempted to support masses so rigid and friable as brick walls on elastic pillars of wood 40 feet long, there was the objection, that to get the shores put up the whole of the ground and first floors would have to be removed, and the walls thereby deprived of valuable lateral support, where they were likely to be unduly strained by unavoidably unequal shoring. The expense also of providing suitable foundations for the shores, increased by the difficulty of getting such long and heavy timber into its place, would have been very great.

In the block plan of part of the building, Fig. 1, the darkly shaded portions indicate the walls that have been removed. As the beams to be introduced at A, C, and D, to support the superstructure, were all to be on the same level, and rigidly connected by bolts and rivets, it was very desirable for facility of manipulation to have them all loose in the walls at the same time. Had the system of timber shores been adopted, to attempt this would have been very hazardous, if not impossible, as the multitude of supports would have rendered the lifting and placing of the beams very intricate.

Fig 1.



To overcome these objections Mr. Geoghegan determined to make the lower portions of the walls, which he ultimately wished to remove, serve as temporary pillars to support the upper parts he wished to retain, by interposing frames of iron or wood, through which the beams could be passed. He accordingly explained his views to the author, and intrusted him with the construction of the shoring frame, which it is thought is a new feature in the art of building.

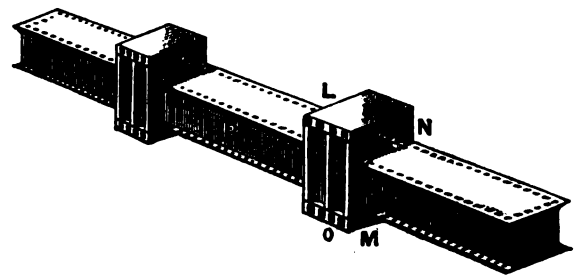
Exclusive of bolts, each frame is composed of four pieces, L, M, N, O, Fig. 2; the top and bottom, L, M, Fig. 2, acting the part of short beams (L supporting the wall above, and M resting temporarily upon the wall to be removed), the two sides N, O, carrying the load as pillars: the beam P passing freely through them. These frames may be of variable dimensions, to suit the depths of beam and thickness of walls or load to be supported; they are fitted together to make a truly rectangular frame, and held in position by means of bolts. The top and bottom L, M, are made cellular, with the outer walls thiner than the inner ones, in order to approximate as much as possible to the form of greatest strength, which would be a series of beams laid side by side L L L.

The vertical pieces N, O, are composed of plate stiffened by deep ribs, to obtain rigidity with lightness, and are provided with holes near the bottom, through which a rod may be passed, to carry a metal roller for the beam to run on when being pushed into its place. As the frames had to be put up in inconvenient places, it was a great object to keep the several parts as light as possible, in order that three or four men might move them with ease, without having recourse to tackle.

There are two principal conditions under which beams may require to be placed under walls—1st, there may be room enough to admit of the beam being launched into its place end on; 2nd, the wall may be so situated that the beam can only be got in sideways; or there may be a combination of the two cases where there may be room to launch the beam half-way if the previous half can be got in sideways. The one case requires a different form of frame from the other, as will now be explained.

Beam D (Fig. 1), supporting two heavy chimney stacks, is an illustration of the first case. There being plenty of room in the court-yard to lift the beam to its proper level, clear of all the houses, the following preparations were made:—Two holes were broken through each of the two chimney stacks, and a good bed

Fig. 2.



having been formed in each at the proper level, four of the frames L, M, N, O, Fig. 2, were placed in them. One smaller frame was similarly introduced in the intermediate wall. When all the frames had been carefully arranged in line, folding wedges of good dry oak were driven between the tops of the frames and the superincumbent walls, till the weight of the latter was made to rest entirely upon the frames. The intermediate portions of the walls and chimney stacks between the frames were then removed, and the beam having been hoisted on tall shear legs in the court-yard to the proper level, was launched safely into its place through the frames.

Beam A (Fig. 1), supporting the back wall, affords an example of the second case. The quoins of the adjoining house would not allow the beam to be hoisted sufficiently far back to pass it through frames similar to those used with beam D. It was therefore hoisted diagonally alongside the wall till its end entered a doorway in the bow projection, which allowed it to go far enough forward to clear the quoins when raised to a level and placed at the proper height parallel to its permanent position, and in which it was temporarily secured. Two of the frames made to project its own width on one side of the wall, were inserted into holes which had been previously cut in the brickwork, and bolted together so as to include the beam within themselves. The weight of the walls was transferred to the frames, and the portions between them cut away as before, and the beam moved in, first sideways till fairly under the wall, and then launched forward through two more frames into its permanent position. The top and bottom being longer were made deeper and stronger to carry the same load; and the vertical side, which was most severely strained on account of being immediately under the wall, was made double the strength of the outer pillar.

Beam C, which was got into the house with great difficulty, on account of its length, was laid on the first floor alongside the wall it was intended to support, and raised thence to its proper height, where it was temporarily held while four frames were put round it, and secured in the wall in the manner already described. The intermediate masonry having been cut away, the beam was moved sideways into its place under the wall.

At this stage of the proceedings the three main walls, being completely cut through, were supported only on thirteen frames, in which the beams were lying loose; the latter were carefully fitted to each other and firmly secured by means of bolts and rivets, after which the whole mass of wrought-iron, weighing 13½ tons, was adjusted to its exact position, vertically and hori-

* Paper read at the Institution of Civil Engineers of Ireland.

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zontally. Chases were now cut in the lower walls to admit the columns, which having been carefully erected, the weight of the walls on the frames was made to rest on the beams, by driving folding wedges between the top piece of the frame and the top of the latter, to cause the beams to deflect to their full extent previous to under-pinning with brick in cement between the frames. When this had been done the wedges over the frames were cautiously slackened, and the entire weight of the building allowed to come upon the beams and columns. The frames were retained in position for a few days, during which the behaviour of the columns and their foundations was carefully watched, and as no signs of yielding were detected the frames were released, the bolts connecting their several parts withdrawn, they themselves removed piecemeal, and the gaps occupied by their upper portions made good in brick and cement. In this manner each of the eight walls was treated most successfully, great care having been taken to insure the full weight of walls being placed on the beams before the under-pinning was commenced, as any subsequent deflection would have caused the walls to crack.

As the frames used were only required for temporary purposes, the castings were returned to the makers, and cost the builder only £5 per ton, at which rate, making allowance for fitting and bolts, the large frames cost £3. 10s. each, the small ones £2. 15s. each. Four men were able to put up three small frames per day, at an elevation of 26 feet from the street, in holes prepared for them previously, and take them down again at the rate of four a day, at a cost of 1s. per cwt.

The actual cost of the shoring upon the system described was £62, exclusive of breaking holes in the walls, and wedging upon the frames. The builder's estimate for the same operation, without any allowance for the great risk run, was £168 to £180, being a saving of at least £106 in favour of the frames, not counting the gain in time, security, and convenience. The urgent necessity of completing the work in the least time possible induced the builders to use more frames than were absolutely necessary; had there been no occasion to shore all the walls simultaneously, the work could have been done for £42, or one-fourth the estimate quoted above.

The beams on which the walls now rest are all made of wrought-iron, with plate sides stiffened by angle-iron, most of them being double-sided or box beams, and so proportioned that no parts in compression should be strained to more than 4 tons, and in tension to 5 tons, to the square inch. They were all tested before leaving the works, in presence of the architect or one of his assistants, by loading the centre of each span to the extent of half the distributed load they were calculated to carry. As there is nothing remarkable in the details of their construction, the following table will give sufficient information respecting them:—

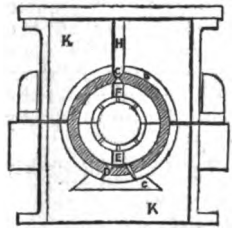
Letter of reference to Fig. 1.	Span. feet.	Span. inches.	Depth. feet.	Calculated load. tons.	Weight of beams. cwt.	qrs.	lbs.
A	18	8½	18	68	83	0	14
A	16	5½	18				
B	15	8	18	80	15	1	0
C	18	10½	18	80	74	0	0
C	16	5½	18	64			
D	18	0½	18	90	109	2	12
D	17	0	18	100			
E	16	0	18	84	9	2	0
F	18	6	21	58	33	2	0
J	18	5½	18	60	36	0	0

The figures in the fourth column, representing the load the beams were calculated to carry, are not the actual weight of the walls resting directly on the beam only, but in addition the mechanical effect of the cross beams resting on the main girders, and throwing concentrated pressures more or less near the centres of the girders they rest on. The cost of erecting the beams at a height of 28 feet from the level of the street, including deterioration of tackle, amounted to £1. 10s. per ton.

The design and execution of the columns was matter of the most anxious attention, on account of their unusual length, the great loads they were intended to carry, and the architectural necessity of diminishing their diameters to the utmost extent consistent with safety. The dimensions finally adopted were, length 26 feet, diameter of base 14 inches, diameter of head 12 inches, thickness of metal 1¼ inch. The ultimate strength of this pillar, according to Hodgkinson's practical adaptation of Euler's formula, was 770 tons, and the safe load may be estimated at one-sixth of that amount. Having decided the proportions of the column, it was of the utmost importance to secure good sound casting, straightness, concentricity of bore to the external surface, and perfect bearing with flat ends on a good foundation. Soundness of casting and straightness were alone to be obtained by careful moulding and ventilation, but the certainty of obtaining uniformity of thickness required special precautions.

It is well known that in moulding columns the hollow part is formed by means of a "core," composed of a perforated metal pipe, wrapped with hay and plastered with loam till it assumes the proper shape and size. This core is placed horizontally in the external mould, and held securely in the sand at both ends, "chaplets" or supports of tinned iron being placed in addition at intervals throughout its length. These chaplets answer very well for small castings, as the sand of the external mould into which they are stuck has sufficient power to resist the distorting action of the molten metal, but in columns of such length as those here described, they would not be sufficiently secure to be trusted. It was necessary therefore to make a metallic connection between the top and the bottom boxes of the mould and the metal core barrel. This was done in the manner shown in Fig. 3. A is the core barrel with its envelopes of hay and loam; B the column when cast; K the boxes with the external mould; C is a metal chair resting on the cross ribs of the box, covered with about 1½ inch of sand; D is a metal trivet to support the core barrel, through the agency of the block E, which is buried in the hay and loam. On account of its great length the core had to be made in two pieces, and joined togther in the centre when placed in the mould, when the two ends were supported by the method described. When the molten iron runs into the mould, the inferior specific gravity of the core causes a strong tendency to float, to prevent which a block F, similar to E, is buried in the hay and loam of the core; on this a small pillar G, whose length is of the exact thickness intended for the side of the column, is placed, and kept down by the pillar H, and plate-cramped to the top part of the external mould. By taking these precautions it was impossible for any irregularity in thickness of metal to occur without the author's knowledge, as the position of the piece G cast in would betray it at once.

Fig. 3.



The strength of a column is very much influenced by the perfection of its bearing and fixity of its ends, and to insure these the ends of the columns were turned truly in the lathe; and the base, which was 2 feet square, 3 inches thick, was turned on the upper and planed on the lower face. The foundation stone having been set perfectly level, and chiselled to fit the plate exactly, the latter was laid truly in its place, and secured by means of iron dowels run with lead. The upper face of the plate being level, the column when reared on it was of course quite vertical, and in absolute contact with the plate all round. The cap, which was also turned on its under side, was slipped in between the beam and the column, and the space between it and the beam filled with bars of flat iron, and cast-iron cement tightly driven in. Both the cap and base had projections ¼-inch high entering the column to prevent any lateral displacement.

Female School of Art and Design, Gower-street.—The Committee of Council on Education having intimated the necessity of withdrawing their special assistance—£500 per annum—from the Female School of Art and Design, Gower-street, the committee of the school make a public appeal for subscriptions to enable them to continue offering the means of art education to young females to whom the schools at Brompton are inaccessible by mere distance. They state that there is no other school in London, exclusively for females, where instruction is given on five days a week. It is proposed to augment the fees, at present very low; and, if £2000 can be raised by subscription, to purchase or rent convenient premises, by which a saving of expense may be effected, and the school continued at work. The number of students is at present 118, of whom 77 are studying with a view to ultimately maintaining themselves.

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EXAMINATIONS AND DIPLOMAS FOR THE ARCHITECTURAL PROFESSION.

At various times, as opportunity arose for discussing it, the question of the desirableness of instituting examinations for the purpose of issuing certificates of proficiency, or even something akin to a diploma, has been canvassed among the rising members of the architectural profession; many circumstances have concurred to make them feel that the step was a desirable one, and they have accordingly not failed to urge its adoption.

The senior members of the profession could not be expected at first to be so anxious for such a change. Men of experience are wisely reluctant to make any fundamental change in a system of which the working is familiar to them under existing circumstances; they too are by their standing free to a great extent from the annoyance justly complained of by their juniors, that of being exposed to competition with uneducated and incompetent men, who by their want of skill and professional feeling bring the name and calling of an architect into disrepute, and render the public suspicious and illiberal in their dealings with even thoroughly competent professional advisers.

Now however that the number of incompetent persons endeavouring to rank as architects has become considerable, we are glad the Council of the Institute are said to have had the matter under consideration, and that it is not improbable that some scheme may be brought forward by which that body may be enabled to give certificates to candidates, that they have passed an examination in such subjects as every architect ought to be acquainted with.

Such a proposal has in its favour both reason and experience. It seems reasonable, that if the complaint be made, as it certainly is, that a profession is over-stocked, that some method should be taken by the members of that profession, provided it be neither inequitable to some of their body nor injurious to the public, to render admission among them somewhat less open than it now is. If the intrusion of ignorant and ill-instructed persons be found a serious evil, it seems desirable that the proposed change should be just such an one as will tend to exclude them; and if it be felt desirable to assist the social status of a rising profession, no method seems more appropriate than adopting preliminary examinations of the class which have long preceded admission to the "learned" professions, and are now being adopted for the army and navy.

Experience has shown that in the case of the medical and legal professions the plan works satisfactorily, and if we compare the miscellaneous character of English dentists with the respectable position of American dentists, or English chemists and druggists with French "pharmaciens," we should find that the necessity of undergoing an examination has raised the character of these two classes of men in a remarkable degree.

It will perhaps be objected that skill as much as knowledge is required in an architect, and that no examination can be a fair test of skill. The reply is, that this objection might be urged with far greater force against examinations for medical degrees, which yet are universally held to have been advantageous; for, inasmuch as the most special mark of the skill of an architect is his ability to work out at his desk and drawing-board an edifice which when erected shall prove successful, it would be quite possible to make examination a test of skill. This discovery of skill however may be fairly left to the discernment of the public: the easiest task is to test the knowledge of candidates in those points of construction and those general first principles of architectural arrangement, style, and detail, ignorance of which could not fail to produce misfortune even where skill in some points may be said to exist.

Examinations of this description have been for some time carried on by the Institute, but only for persons desirous of becoming candidates for the office of district surveyor in London. These will no doubt form the model for the new examinations, and if made less stringent on the point of actual personal experience, and enlarged so as to insure the existence of some knowledge of the history of architecture and of the leading features of different styles, and at least a competent skill in drawing, it will be a good starting point. There ought to be additional honorary certificates for high attainments in any distinct branch, as in construction, Classic or Gothic detail, architectural sculpture, the history or literature of the art, applied mathematics, and the languages of modern Europe.

To attain the proposed end it is by no means necessary to make the examination compulsory; that, if practicable, would require, in order that it might not be unjust, that the standard should be a low one. A much more desirable course, we think, would be to start with a high standard of proficiency, and to make the taking the examination entirely optional, so that a spirit of emulation should be roused, and the possession of a certificate of the Institute should become a mark of distinction, which, because any person may do without it, no man of education and spirit would be willing to forego,

NEW MARINE ENGINE ROOM TELEGRAPH.

The adoption of a mechanical engine-room telegraph, as the means of communication between the officer in command of the ship and the engineer in charge of the engines below, having become now almost general, superseding all other expedients, it is important that the respective arrangements of the signals upon deck and below in the engine-room, as well as the means employed for their transmission, should be reduced to the simplest form.

It is not uncommon to see the signals on the dial of such a telegraph very unsatisfactorily arranged, and altogether at variance with the condition or required condition of the engines. The fact that an engine moving full speed ahead has to pass in succession and in perfect order, although perhaps very quickly, through all the different degrees of speed, and even to stop, before it can assume a retrograde motion; and again, that an engine moving backwards must pass in complete order through all these stages before it can be brought to advance, renders it necessary that the order of the signals should correspond to the various conditions of speed required. Nothing can be more simple than to arrange the signals in a corresponding succession with the speeds, so that the hand upon the dial is retrograding when the speed is required to be slackened, and to retrograde finally, should the hand upon the dial so indicate; and again the hand is advancing when the engines are to advance until both arrive at their positive or negative extremes, that is, at full speed ahead or at full speed astern. Such an arrangement would be similar to the arrangement of the figures upon the dial of a watch: it is more simple and intelligible, at the same time consistent with the degrees of speed of the engine, and more easily read off and understood. When the engines are at full speed ahead, the attention of the engineer is called to the telegraph by the alarum: he sees the hand moving in a retrograde direction, and knows at once that the speed has to be slackened: he follows the degrees indicated successively by the telegraph with the starting lever or wheel until the hand comes to a stop, and so *vice versâ*. The hand upon the dial has to pass through the same degree as the starting lever or wheel of the engine to arrive at any certain point: their direction of action is therefore always in conformity. With the exception of the simplification of the signals described, the general arrangements of this telegraph are similar to others previously adopted. The motion of the handle on deck is transmitted as usual by means of a series of shafting and tooth-wheels where necessary. The alarum-hammer is directly attached to a spring, and is acted upon by a wheel having on its circumference a series of evolute-cogs, the same in number as the signals upon the dial To insure the sudden release of the hammer in order that it may strike the bell effectively a peculiarly shaped cam is mounted upon it, which, after being raised by the above-mentioned wheel to the requisite extent, allows the alarum-hammer to fall and to react without meeting with any hindrance which might impair its free action should the wheel not be moved quick enough. This arrangement dispenses with the use of several springs and hammers, without diminishing the number of the required signals. This telegraph is patented by Messrs. M. A. Soul and Co., of Leadenhall-street, London.

The Panoramic Lens.—In the 'Photographic Journal' is a description by Mr. Sutton of a new lens for taking panoramic views. In its simplest form this lens consists of two concave lenses of glass, forming portions of a spherical shell, and having the spherical cavity between them filled with water. The glass, which has the highest refractive and dispersive power, is made into the two concave lenses, and the water in a convex lens, the combination being achromatic. Pictures are taken with this new lens quickly and clearly.

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BUILDING STONES: THE CAUSES OF THEIR DECAY AND THE MEANS OF PREVENTING IT.*

By George R. Burnell, C.E.

In a district of so peculiar a nature as that of the environs of London, where clay of a highly plastic description occurs in great abundance, the style of construction adopted is so markedly characterised by the use of the local material, brick, that we inhabitants of London are apt to forget that other districts are as it were compelled by analogous circumstances to adopt a style which is diametrically opposed to our own. In London, and indeed in a large majority of our centres of population, bricks are habitually cheap and good—stone is rare and expensive; and it thus happens that stone becomes to us an object of luxury, only to be employed in monumental structures, or in the decorative parts of ordinary houses. In France the contrary rule prevails, as it does likewise in some of the towns of Yorkshire and of Scotland; and there stone is the common material used in building, and brick the exceptional ornament. It has always seemed to me a matter of regret that this should be the case, for beyond question the taste of the London builders has been injuriously affected by the small and unbending character of the material they habitually employ; whilst the grander and more monumental appearance of such towns as Edinburgh, Bradford, Paris, &c. may to a great extent be attributed to the fact that in them large ashlar stone is habitually employed. But in addition to this æsthetical inconvenience arising from the absence of ashlar stone as an ordinary material of construction, the builders of such towns as London labour under the more serious one of being less acquainted with the nature and properties of stone than are the builders of more favoured localities; and we therefore find, that even when the former do resort to the more costly materials, they frequently employ them under such circumstances and in such positions as to expose them unnecessarily to danger and decay. Emphatically this has been the case of late years with respect to many of the London buildings, and it may under such circumstances be desirable to dwell for a short time upon the nature of the stones which usually appear in our market, and upon the various injurious actions to which they are exposed.

The building stones employed in London are capable of being divided, according to their mechanical properties, into two classes, namely, those which can only be worked by the pick or wedge, and those which can be worked by the mallet and chisel,—the latter being known by the name of freestones, in contradistinction to those which do not work freely. These classes in their turns are susceptible of numerous subdivisions, such as, in the first class, the granites, porphyries, basalts, whinstones, and the countless varieties of the plutonic and volcanic formations; the quartz rocks, mica schists, gneiss, and the more dense altered quartzose sandstones, the quartzose conglomerates, and the grès or agglutinated sandstones of the secondary and tertiary strata. The slate rocks perhaps might be grouped as a sub-class of the stones not workable by the mallet and chisel, for they present too decidedly marked a cleavage to allow of their being worked freely, though they are susceptible of being sawn, or even worked on the edge, in the same manner as the freestones themselves. In the second class, or the freestones, are comprised the marbles, sandstones, limestones (both carbonates and sulphates), in all their endless modifications. The bituminous rocks furnish materials which may be classed as a sub-variety of the freestones, in an analogous manner to the classification of the slate rocks in the preceding division.

Of the stones above described as being of the first class, the London market consumes large quantities of granite from the Channel Islands, Cornwall, and Devonshire, Mount Sorel in Leicestershire, Aberdeen and Peterhead in Scotland. The whinstones, basalts, and volcanic tufas are hardly ever seen here—unless in the form of the pozzuolanos and trass, which are occasionally imported from Italy and Germany for making artificial hydraulic cements—whilst the quartz rocks and the quartzose sandstones, the mica schists, &c. are never used. The quartzose conglomerates, such as the Bramley Fall stone, are occasionally employed in engineering works, and the tertiary grès, or sandstones of Windsor Forest, are used in the neighbourhood of Windsor as paving materials for streets and stables, just as the grès of Fontainebleau, their geological analogues, are used in Paris. The advantages offered by the best of these various materials consist in their extraordinary hardness, their density of texture, their non-absorbent properties, and generally speaking their powers of resisting atmospheric influences; but the whole of this class is exposed to the serious objection that the labour upon all its varieties is very costly; and that from the mere fact of their being composed of heterogeneous ingredients in the far greater number of cases, they are also exposed to the action of causes which are able to produce either disintegration or decomposition of their elements. Thus for instance, the Cornish and the Devonshire granites, and some of the porphyries and elvans from those counties, frequently contain a notable proportion of felspar; and when they are exposed to the action of rain-water, containing (as it usually does) carbonic acid in solution, that felspar decomposes, and is then easily removed, leaving the quartz and the mica in relief, without any cementing material. Illustrations of this mode of decay may be observed in the granite used in parts of Waterloo and London bridges, or in the granite piers of the crypt under the hall of Christ's Hospital; but the process is very slow, and it would seem to be subject to some laws not hitherto discovered; for the decay of the felspar does not take place according to any known rules. The more crystalline, in fact, the felspar of any of these bodies may be, the more perfectly does it resist the decomposing action of the atmospheric agents. We shall again allude to the influence of this mechanical state of natural substances upon their durability. In the Bramley Fall, and in the analogous stones, the siliceous conglomerates, the same phenomena may be observed. The cementing material frequently decomposes, and is washed away from the ingredients it naturally held together, and then the latter as certainly fall asunder; or the cementing material decays, and in so doing it produces a dangerous disintegration of the mass. It follows that the smaller and the more uniform in dimensions the materials of these heterogeneous rocks may be, the greater is the probability of their duration; and in the case of granite especially it is essential to select those descriptions which do not contain large crystals of felspar. It is singular that some of the granites of Normandy, Brittany, and the north of Spain present identically the same mineralogical peculiarities as the granites of Devon and Cornwall, and they are equally susceptible of decay. The varieties in the lithological characteristics of the Bramley Fall stone, and in those of the quartzose conglomerates, are still more hard to define than even those of the plutonic rocks: in the same quarry, and even in the same bed, the qualities of these stones will change within a very small distance, and the great irregularities of this description of stone form in fact the most serious objection to its use. Nevertheless, when the Bramley Fall or the siliceous conglomerates are well selected, they are extremely valuable for engineering purposes, on account of their hardness, and of their power of resisting crushing weights. They yield to atmospheric influence when the siliceous cement exists in the form of soluble silica, and is of an amorphous character; if, on the contrary, the cement assume a crystalline character, it becomes unattackable even by caustic alkaline solutions, and the siliceous conglomerates are then as durable as the best descriptions of granite themselves. Of the granites which are used in London, those obtained from Aberdeen, Peterhead, and Mount Sorel are the most valuable; but also, on account of their hardness, the most expensive. They can be obtained of any required dimensions, and are capable of receiving any desired form, and thus are admirably adapted for the construction of buildings of a simple monumental character, designed "not for an age, but for all time;" their colours moreover are agreeable, especially those of the rose tinted granites of Peterhead and Mount Sorel. The best siliceous conglomerates used in London for building purposes are extracted from the lower members of the Yorkshire coal field; their colour is far from being as agreeable as that of the good granite, and at times, when there is much oxide of iron in the cementing material, the colour of the conglomerates becomes unpleasantly foxy.

For the reason above cited, namely the difficulty of working the first class of stones, the other or the freestone class is the one most generally used in building operations, the selection of the variety employed in any locality being too often only regulated by the consideration of its ultimate cost. In London the freestones commonly used may be stated to be as follows:—Amongst the sandstones, the Craigleith, the Dundee, and Arbroath, the Yorkshire stones, and the sandstones furnished by the Wealden deposits near Tunbridge Wells, or by the subcretaceous formations of the neighbourhood of Godstone, Maidstone, or Folkestone; amongst the magnesian limestones, the Anston

* Paper read before the Society of Arts.

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and Bolsover stones; amongst the carbonates of lime, the Portland, Purbeck, Ketton, Barnack, the Caen, Ranville, Aubigny stones, are to be met with in commerce without difficulty, whilst it would be easy to increase their number by the introduction of the remarkaby valuable tertiary limestones of the Paris basin. In some localities even the common chalk becomes so indurated as to allow of its being used as a building stone,—less frequently, it is true, in England than in France, for in the valley of the Lower Seine this material is extensively used in the best buildings, as at Rouen, Vernon, Louviers, &c.

The Craigleith stone, of which the majority of the buildings of Edinburgh are constructed, is occasionally used for foundation or basement works in the metropolis, or for staircases exposed to great traffic; but the hardness, and consequent high price of labour, of this stone limits its use to such situations. The weight of a foot cube of the Craigleith stone is about 146 lb., and it is stated to resist a crushing weight of 5800 lb. on the inch superficial. Generally speaking the colour is a greyish white, and in consequence of the density and the non-absorbent character of the material, it retains a clean appearance for a very long time. The London atmosphere has very little action upon it.

The Dundee and Arbroath stones are sometimes employed in London, the former as an ordinary building stone, the latter principally as flag pavement. The colour of the Dundee stone hitherto brought to London is rather disagreeable, for it is a dark purplish brown, or a deep oxide of iron tint, but the stone is hard, and resists weather very satisfactorily: in consequence of the colour however, this material is never used in ornamental buildings. The Arbroath stone is of a denser character than that obtained from Dundee, but it is more decidedly "flaky," to use a workman's phrase, and it is therefore almost exclusively used for the purposes above mentioned. Occasionally however blocks of the largest dimensions, and of uniform character, are obtained from the Arbroath quarries. They are hard; they resist weather satisfactorily; the stone is easily worked, and the colour (a light greenish grey) is far from being disagreeable. I am not aware of any observations upon the specific gravity of this stone, or of the crushing weight it would bear, but, judging simply by the eye, I should be disposed to class it in these respects with the Yorkshire sandstones, to be noticed hereafter. As Arbroath lies immediately upon the seaboard, it is strange that the stone from that locality should not be more commonly used in the metropolis.

There are several varieties of the Yorkshire sandstones used in London, of which the most generally known are the flagstones from the neighbourhood of Halifax and Huddersfield, and the compact stones from the vicinity of Leeds, commonly called the Park Springstone. The weight of a foot cube of the paving stone is about 145 lb., and the crushing weight it can support may be considered to be nearly equivalent to that of the Craigleith stone. It is worthy of especial remark, that though the Yorkshire flags absorb water freely, and part with it in as easy a manner, they do not suffer from the action of frost; it may be because their distinct lamination allows the expansion of the water to take place freely in a horizontal direction. But when the Yorkshire stones are used in vertical walls, they are not able to resist the singular destruction which takes place at the extremity of the zone of capillary action in almost all porous stones. They do not in fact, to use another workman's phrase, "stand well between wind and water," and should not therefore be used in the basements or in plinths of buildings immediately in contact with damp earth, or in positions to which water has access at irregular intervals.

The Tunbridge sandstone has been occasionally introduced here, but with very unsatisfactory results. No doubt it would be possible to select stones from the Wealden deposits of Tunbridge or elsewhere which would resist the action of the atmosphere; but with the exception of the limestones of this series of deposits, to be noticed hereafter, the materials derived from these beds are of far too irregular and too dangerous a character to allow of their being used at any distance from the place where they are obtained.

The sandstones of the subcretaceous rocks are also of a very irregular character, and even when of the best quality they are but ill qualified to resist alternations of wet and dryness. Nevertheless, the Godstone and Maidstone firestones, as they are called, are of great value in the arts, on account of their powers of resisting the action of fire. When these stones are used for ordinary building purposes they require to be kept above the ground, or from the influence of capillary attraction upon the moisture it may contain, and also to be protected from rain by being covered by some impermeable material. If these precautions be observed the firestones do not rapidly decay; and in some of the oldest parts of Westminster Abbey, or of the Temple Church, specimens of them may still be seen in a fair state of preservation. For internal elaborate Gothic tracery the firestones may be advantageously employed, because the ease with which they are worked reduces the cost of labour of such decorations. The colour, a greyish light green, is far from being unpleasant.

While thus speaking of the subcretaceous building stones, it may be as well, even at the risk of a little departure from the strictly logical classification according to the nature of the materials, to call attention to the Kentish rag, which is now so extensively used in the modern revival of mediæval architecture. This stone is a limestone, with a very small proportion of earthy matters, frequently subcrystalline, but ordinarily of a confused texture, the beds from which it is obtained varying from about 6 inches to 3 feet in thickness, and the colour varying from a lightish green to a deep blue. The stone is, when well chosen, very hard and dense; and indeed the labour upon it is so expensive that it is very rarely that the ragstone is used for anything but rubble masonry in districts remote from the quarries. It is the custom at the present day, on account of the expense of working this stone, to execute all the moulded or decorated parts of churches, &c. in Caen or Bath stone, and even to carry up the quoins of those materials, whilst the intervening spaces are filled in with the hard rag. In other words, the exposed parts of such fashionable specimens of construction are executed of soft and yielding materials, whilst the protected parts are executed of hard and durable ones. However, the walling thus produced is certainly picturesque in its effect; and if some of the processes for the preservation of some of the softer stones, to be noticed hereafter, be applied to the Caen and Bath quoins and copings, or weather-tables, there can be no valid objection to the use of the Kentish rag in connection with them, on the score of the durability of the work at least.

Of late years, in consequence of the report of the commission named for the selection of the building stones for the new Houses of Parliament, the magnesian limestones from the Anston and Bolsover quarries have been largely used in the metropolis,—in some cases, as in the Museum of Economic Geology, with tolerable success; in others, as in the Lincoln's-inn Library and the Houses of Parliament, with a precisely opposite result. This discrepancy proves at least that the magnesian limestone is quite as much exposed as any of the formerly used building stones to great varieties of composition; and therefore much attention must be paid to its selection and mode of application. The colour of the best varieties of this stone is of an agreeable light warm and ferruginous brown; its density is rather greater than that of the oolites; the labour upon it is intermediate between that upon the Yorkshire and the Portland stones, and it can be obtained in blocks of any required dimensions. For many reasons the use of a stone presenting the external characters of the magnesian limestones would be very desirable, and it must be a subject of sincere regret that so little care should have been displayed in the selection of the varieties employed for the important buildings we have above referred to. The decay of the stonework in the Houses of Parliament is really painful to witness—I had almost said shameful.

With the exception of the Purbeck, the other freestones before cited as being used in London are obtained from the oolitic series. It must not however be understood that the oolites are the only valuable sources of supply, for very valuable limestones adapted for building purposes are to be found amongst the transition rocks and the mountain limestone districts of Devonshire and of the midland counties, whilst the blue lias itself is frequently adapted to such uses. But in the first place, the materials yielded by the transition and by the mountain limestones are so hard and so difficult to work, that they are never able to be used beyond the immediate neighbourhood of the quarries; and in the second place, the purer varieties of the limestones from the blue lias series are so irregular in the thickness of their beds and in their powers of resistance, that they are equally avoided in general use. The tertiary limestones of the Paris basin might no doubt furnish building materials of a very superior description to those usually employed; but they are comparatively speaking unknown in England, and certainly they never appear in the London market. In fact, the only lime-

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stones habitually used in the metropolis are those obtained from the oolitic series, and amongst them the Barnack, Ketton, Ancaster, Portland, Bath, and Caen stones, are those which are most generally known to our architects and builders.

Of these stones, the Barnack stones obtained from the oolite of Northamptonshire, figure to some extent under a false name, for the real Barnack quarries have long since been abandoned, and in their place the Casterton stone is now commonly employed. Both the original Barnack and the Casterton stones are of a lightish brown colour, and they are composed of a tolerably pure carbonate of lime of a compact but oolitic character, and containing an infinite number of fragments of shells and corals. Their specific gravity is about 2·09; the crushing weight (instantaneous) would seem to be about one-fourth of that of the Craigleith stone, though there are some marked discrepancies between the results obtained from the respective materials. Nearly all the mediæval structures of Cambridgeshire, the Isle of Ely, and the north of Suffolk, were executed in the Barnack stone, which certainly has resisted atmospheric influences in a very remarkable manner, when care had originally been taken to select for the more dangerously exposed positions the less earthy varieties.

The Ketton oolite, which was largely used in the erection of the numerous churches in Northamptonshire, and has even of late years appeared with successful practical results even in London itself (as in the tower of St. Dunstan's-in-the-East), is very much like the Barnack stone in colour, but is more regular in its character, harder, and more difficult to work, and from the singular apathy of the quarry holders it seems even to be more costly in the first instance. The Ketton stone is of a rather warm cream colour; its specific gravity is about the same as that of the Barnack stone, and the crushing weight it will bear is rather greater than that required to destroy the latter. If this material could be brought at a cheap rate to London, there would be little doubt of its being extensively used; for the original colour is decidedly pleasant, and the London atmosphere seems, from the state of the tower of St. Dunstan's, to have very little action upon the Ketton stone, either in producing decay or in changing the colour.

The Ancaster oolite is obtained from Lincolnshire, and it is largely used in our midland counties, on account of the beauty of its grain, its pleasant colour, and the ease with which it is worked. Its specific gravity is greater than that of the Barnack stone, and its cohesive force is also greater. This stone is however but little known in London, and until it has been exposed for some time to our peculiar atmosphere, it would be dangerous to pass a decided opinion on its merits. In Lincolnshire and the midland counties the Ancaster stone, it may be observed, has resisted the ordinary causes of decay very satisfactorily, and with proper care there can be no *primâ facie* reason why it should not succeed in London.

The Portland oolite is the material which is most frequently used for the higher class of buildings in London, and which certainly has stood the action of time and atmospheric changes more satisfactorily than any other stone introduced on a large scale. The colour of the Portland stone is at first of a rather cold chalky white, and indeed it is always rather objectionable, though the rapid accumulation of soot which takes place in London renders the consideration of colour one of very minor importance. Blocks of any required dimension can be obtained from the Portland quarries, and the stone is hard, dense, usually free from shakes or vents of a serious character, and yet it is easily worked either by the chisel or the plate saw. The ordinary weight of a foot cube of this material is 147 lb., and the load it would bear is stated to be about 3279 lb. per inch superficial. The upper beds of the quarries are used in some public works, under the name of "roach;" they are specifically lighter than the common beds, very full of fossil shells, less distinctly oolitic in character, and from the more perfectly crystallised character of the carbonate of lime, which forms the cementing material of the mass, they are better fitted to resist alternations of dryness and moisture. It is for these reasons that the Portland roach is so extensively used in docks, piers, and other hydraulic works. The stone obtained from the eastern side of the Isle of Portland is very inferior in quality to that obtained from the western side, a fact of which the architects of the time of Sir Christopher Wren seem to have been aware, but which did not seem to have attracted the attention of their successors of some thirty years since, for the stone used in St. Paul's, the city churches, Somerset-house, &c. has stood remarkably well, whilst that used in the gates and screen of Hyde and Green parks has decayed. The former was obtained from what are locally called the West Cliff quarries, the latter from the East Cliff, or near the extremity of the island.

The Bath stone is obtained, as its name implies, from one of the members of the great oolite in the neighbourhood of Bath. In colour this material is more agreeable than the Portland stone, and its texture is very similar, but it is softer (so much so indeed as to allow of its being worked with the tooth saw), and more absorbent; and therefore, unless precautions are observed in the manner of using the Bath stone, it is exposed to rapid decay. Some very painful illustrations of this fact may be witnessed about London, and amongst others the restoration of Henry the Seventh's Chapel may especially be cited. The weight of the foot cube of Bath stone is about 123 lb., and the load it will bear before crushing is estimated to be 1800 to 2000 lb. per inch superficial.

The Caen stone is obtained from the great oolite of Normandy, near the town of that name, and is much used in building operations in London, on account of the beauty of its grain and colour, and of the ease with which it is capable of being worked; for when freshly quarried the Caen stone can be cut with the toothed saw and carved with ordinary carpenter's chisels, even more easily than the Bath stone itself. The upper beds of the quarries near Caen yield stones of small dimensions, but of a much more durable nature than those furnished by the lower beds. Unfortunately, however, the requirements of architects have induced the stone merchants to abandon of late years the material of superior quality, in order to secure the large blocks now so universally called for; and thus the reputation of the Caen stone has rather unjustly suffered. But it is perhaps advisable here to remark that in the public buildings of the town of Caen, the local material is not usually employed in positions where it would be exposed to the rainfall, or be able to absorb water by capillary attraction; and that the basements, or the exposed parapets, towers, or steeples, are built of other and more resisting stones. The weight of the Caen stone is about 120 lb. per foot cube, and its crushing weight about 2000 lb. per inch superficial.

In addition to the Caen stone, the oolite of Normandy supplies the London market with a material of great beauty known by the name of the Aubigny stone, which is harder, finer in its grain, more crystalline in its structure, and able to support a greater crushing weight than the Caen stone. From the fearful state of decay of the mediæval buildings of Falaise, the town in immediate proximity to the Aubigny quarries, it may however be suspected that this material would not be of a durable character, notwithstanding the fact that the supply is now obtained from different beds to those formerly worked. But there are other stones to be obtained from Normandy, which might furnish our builders with extremely valuable resources, such as the Ranville, Fontaine Henri, Creuilly, Courseulles, and Quilly stones; unfortunately they are little known amongst us, and the prejudice against the use of Caen stone (in consequence of its failure when injudiciously employed in such buildings as Buckingham Palace, Mr. Hope's mansion, &c.), has extended to the whole group of Norman stone.

All these varieties lately mentioned as coming from the oolitic series are characterised by the remarkable purity of the carbonate of lime which constitutes the basis of the stones. The carbonate is often sub-crystalline, and generally speaking assembled in minute globules, similar to the roe of fishes, from whence the formation derives its name. Many shells and vegetable and animal remains occur in some of the varieties, and they give rise to some peculiar and hitherto unexplained conditions of durability in the stones. Thus, when the *test* of the shells has been replaced by the decidedly crystalline carbonate of lime, they assume a remarkable degree of hardness, and if present in sufficient numbers they communicate great powers of resistance; as in the case of the Barnack, and the Roach Portland; but this influence of the shells may be imperceptible if the cementing material should happen to be of an earthy or of a soluble character, and if much organic matter should be present it would allow the formation of certain salts when the stone is exposed to air and moisture, which would seriously endanger its cohesion. The fossils also tend to define and separate their beds, and thus to render it more than usually necessary to pay attention to the practical law, that "stones should always be used bedwise;" and here it may be advisable to remark, that whenever the materials of a stone have not been affected by their proximity to any source of igneous action, they will not admit of the stones being used in false bedding, although

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some varieties of the Jurassic limestone, or of the tertiary deposits of the Paris basin, are occasionally used in such positions without any immediate or apparent risk. Nearly all the oolites yield a pure rich lime of great service in agriculture, but of little real value in building operations (on account of the solubility of the lime), unless mixed with some form of soluble silica. The blue lias lime, which contains a large proportion of the silicate of alumina, is however much used for hydraulic works.

The Purbeck limestones were formerly much used in London for paving footpaths, and some varieties were worked for sinks, troughs, or cisterns, under the name of the Purbeck Portland, but the irregularity of hardness and the small dimensions of the Purbeck flags have led to their almost universal abandonment in favour of the harder and more uniform Yorkshire stones. The Purbeck and Petworth marbles were formerly much used in ecclesiastical decoration, and when placed bedwise they have resisted the action of time very satisfactorily, provided always that the earthy variety had not been used. Some of the shales of the Wealden series are occasionally used to cover the roofs of buildings in Sussex, but their weight, and their very irregular texture, oppose their general application at a distance from the quarries.

Causes of Decay.

Now the conditions under which the stones above described decay when they are placed in a building are partly mechanical and partly chemical. Of the former the most important are, 1st, the dissolving properties of atmospheric moisture, in its various forms of rain or mist; 2nd, the disintegrating action of changes in atmospheric temperature. Of the latter, the most important are, 1st, the chemical reactions which take place in the ingredients of the stones themselves; and, 2nd, the new forms of matter which are superinduced from without of a nature to affect the stability of the original combination.

The dissolving power of atmospheric moisture seems to depend greatly upon the quantity of free carbonic acid gas it holds in solution, and though this quantity in any given volume of water be extremely minute, in course of time every substance which has an affinity for it will yield more or less to its action. The silicates of potash and soda, for instance, which are present in the igneous rocks—or, to dwell especially on the class of materials under our notice, in the Devonshire granites—are easily decomposed when rain-water falls upon them; and, the felspar being removed mechanically by any of the countless actions of nature, it leaves the other ingredients of the material exposed to the mechanical disintegration of changes of temperature. The simple carbonates of lime, again, sometimes absorb carbonic acid with much avidity, and pass into the state of the soluble bicarbonates; and thus, in proportion as the original face of the stone is removed, does the lower surface become exposed to the action of the rain. The rain-water of such a town as London not only does contain large quantities of free carbonic acid, but it also contains sulphuric acid and ammonia, which are capable of exercising a very deleterious influence upon the carbonates of lime. In discussing however the effects of these agents upon building stones, it is essential to bear in mind the fact that the mechanical states of the elements of those materials greatly modifies their resistance. Those which are of a crystalline character do not yield so readily as those which are amorphous, and the crystallisation produced by volcanic or plutonic influence appears to be even more permanent than that which takes place in the ordinary way.

It follows from these considerations that the stones of an irregular, confused, earthy texture, which are able to absorb considerable quantities of moisture, and which contain silica in a soluble form, or the carbonate of lime, should never be employed in positions where rain-water could lodge upon them, beat against them, or be taken up from external sources by capillary or other action. In positions exposed to any of the above dangers, none but non-absorbent and decidedly crystalline materials should be used, and as those qualities are almost exclusively possessed by dense stones, it may be considered that the mere specific gravity of a stone is a *primâ facie* indication of its constructive value.

But atmospheric moisture when absorbed into building stones acts upon them quite as much through the changes in its own volume in passing from the liquid to the solid state at the time of frost, as it does by the chemical dissolution it produces. If the stone should be placed in such a manner as that water should accumulate in any perceptible quantities between its various layers, and if the position of those layers be such that the expansion of the water in freezing cannot take place freely, the respective layers containing the water will be violently detached from one another. Now all stones, even the crystalline limestones and slates, have certain planes or directions of cleavage or of stratification, along which water flows more readily than in any other course. If the stones be placed in a building with those planes in a direction likely to retain rain falling upon, or absorbed through, the surface (which is the case when stones are placed "bed to weather"), disintegration must ensue unless the edges of the beds be left free, and even in that case there is danger of frost detaching one layer from another. It is indeed a primary law of construction that every stone should be laid "bedwise;" and few modern theories have produced so much practical mischief as the one lately propounded, that "it was a matter of little importance in what direction of the bed a stone was laid." Fortunately even unpractised eyes can detect the bedding of the majority of the London building stones, either from the position of the fossils, or the variety of texture or of colour; in the less distinctly marked stones even, practised eyes can detect the planes of cleavage, and a good workman will hardly ever be mistaken in his judgment. It is unfortunate that the modern system of competition throws so great a temptation in the way of the practical builder, as to render it a mere matter of chance whether the constructive law above-mentioned be observed or not, unless a costly system of supervision be organised; and thus the precautions often taken by the stone merchant to indicate the upper bed of the material he delivers are defeated.

In the stones which present distinct traces of bedding it often happens that a difference of the chemical and even of the mechanical structure may be observed to exist in the respective layers about the lines of separation; under such circumstances, when the stones are laid bedwise it is by no means rare to see the softer parts near the lines of bedding removed to a considerable depth from the surface. This action may be observed, amongst other instances, in the Purbeck marble of the pillars of the choir of Westminster Abbey, quite in the protected parts of the building. It would seem that, in this particular case, the more earthy particles upon the planes of bedding are decomposed by the action of the moisture they absorb from the vapours suspended in the atmosphere, and that the cohesion of the various particles being thus destroyed, they gradually fall away. Westminster Abbey furnishes also numerous illustrations of the danger of placing stones, of whatsoever description they may be, in any other than the natural bed; for even a glance at the sheltered parts of the north transept, in the churchyard, would enable anyone to detect by their conditions of decay the stones which have been laid well or ill.

The chemical reactions which take place in building stones (other than those resulting in the interior of the country from the agents directly presented by atmospheric moisture in the form of carbonic acid gas, sulphur, and ammonia, or upon the sea shore in the form of hydrochloric acid, or of common salt itself in minute particles), are mainly those arising from the oxygenation or the hydration of the various ingredients of which those stones are composed. Thus, if the oxide of iron be present in any notable proportions, it is likely to undergo changes of a nature to disturb the stability of the compound, and even the crystalline sulphates of lime are exposed to chemical decomposition, in consequence of the liberation of the sulphuric acid gas they contain. The other mineral salts, such as the silicates and the sulphates of iron, so often met with in building stones, are at times susceptible of very injurious decomposition; and the soda, potassa, or the organic matters the stones may contain, as frequently give rise to the formation of new salts; mainly under the action of the atmospheric moisture, it is true, but also under the influence of the partial decompositions which take place around them. It is to be observed, however, that the danger to building stones from this peculiar class of influences is very small and very slow in its action, compared with the dangers arising from the mechanical disintegration produced by atmospheric causes; and that, with the exception of the action of free carbonic acid upon the felspar of granites, of the changes of state produced in limestones by the same agent, and the modifications of the abundant salts of iron in some peculiar stones, there is little practical necessity for dwelling upon this interesting but obscure branch of applied chemistry.

The actions capable of affecting the stability of the composition of ordinary building stones, by reason of the new forms of matter they superinduce, may principally be considered to be those re-

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sulting from the absorption of the gases of the atmosphere, and especially the extraordinary process known by the name of "saltpetreing," or more correctly speaking, of nitrification. This process displays itself in the formation of minute crystals, efflorescing from the interior to the exterior of the stone, and it leads to the destruction of the exposed surfaces of the latter, through the gradual removal of the minute particles, in consequence of the disintegration produced by an expansive action of the crystals in process of formation. It is supposed that the organic matter diffused through nearly all stratified deposits gives rise to the formation of certain nitrates (such as the nitrate of lime or the nitrate of soda) under the influence of damp and of air, and of light of certain descriptions—for nitrification certainly takes place most abundantly near damp ground, rising in a wall *pari passu* with the range of the capillary attractions of its materials, and upon the northern or shaded faces of the said walls. Not only does this nitrification throw off the minuter and less adherent particles of the building materials themselves, whether they be stone or brick, but it is also able to detach any protecting coat which may be put upon them, if the adhesion of that coat to the subjacent material should not be of a very energetic nature. Let the adhesion however be ever so energetic, if once the action of nitrification should have been established, it must run its course, and the amount of evil it is capable of producing will simply depend upon the quantity of organic matter originally contained in the materials or susceptible of being absorbed by them from the atmosphere. The secondary limestones which have not been affected by plutonic action, the loamy clays, some kinds of pit sand, sea sand, and some descriptions of natural cements, are particularly exposed to the danger of nitrification in damp positions; and whenever it is once established it is in vain to expect to be able to preserve any mural paintings, or even any sculpture of a delicate character. It is also to be remarked that nitrification will frequently take place in the most dangerous manner precisely in those materials whose exposed surfaces are covered with coatings impervious to the air; and that in houses or buildings of that character it is most energetic on the interior faces of the walls, or precisely on those which are the least exposed to the atmosphere. In fact, it is mainly in consequence of the absorption of moisture by the building materials, and of the chemical changes thus produced in the organic matter those materials may contain, that the peculiar form of decay which accompanies "saltpetreing" arises.

Prevention of Decay in Stone.

Practically then the great agent in the destruction of building stones, in any of its modes of exhibition, is the damp or the water supplied by the atmosphere either directly or indirectly, and the efforts of those who seek to prevent this destruction must be directed to combating this primary source of evil. Fortunately the precautions to be observed for this purpose are very simple, and they only require a little common sense on the part of the builders charged with their application to the materials at least which have been long before the public.

The first and foremost rule is never to employ a porous absorbent stone in the ground or in elevation; unless in the former case it be maintained constantly wet, or unless in the second the absorption of moisture from the ground be prevented by the interposition of some impermeable material. Stones of the description just mentioned should never be employed for the copings, parapets, window-sills, weather beds of cornices, plinths, strings, or other parts of a building where water may lodge. Care must also be taken to bed such stones with mortars which are not exposed to develope in themselves, or are not likely to excite in the stones, the efflorescence of any of the nitrates of soda, potassa, or of lime. If porous or absorbent building stones must however be used in exposed positions, and no efficient precautions be taken to prevent their decay, it will be found that the decay will commence and be most apparent in the zone of alternate dryness and humidity, or, as the workmen say, "between wind and water." The stonework about that zone should therefore be executed in such a manner as to allow of its being easily replaced, if requisite, and in case the exhibition of the decay should take place towards the interior, care must be taken to isolate the decorative plastering or wall linings from the surfaces which are likely to be covered by effloresence. These precautions are after all only very unsatisfactory palliations of an evil which ought never to exist, and it is therefore advisable to direct the attention of our English builders to the practice of their French neighbours, who use different stones according to their position in a building. In Caen itself, for instance, the plinths or basements of houses are executed in granite, or in the Ranville, Cherence, or Creuilly stones, which are practically non-absorbent; and moreover in the best buildings the Creuilly stone is used for the exposed parts of the elevation, although the Caen stone is found at the very gates of the town.

But even when every precaution has been taken to prevent the absorption of moisture from the ground, or the actual rainfall, it is necessary to protect the exposed surfaces of the soft and absorbent stones by some coating which shall prevent their taking up the injurious moisture from the air. This is done in various ways; 1st, by painting; 2nd, by impregnating the exposed surface with oleaginous or fatty matters; 3rd, by washing the face with some solution able to convert the material itself into an insoluble non-absorbent substance; and 4th, by filling in the pores of the stones with an insoluble material which should effectually exclude water.

1st. The objection to oil paints consists in the fact, that in proportion as the oils which serve as their vehicles evaporate, the particles of the stone they originally protected become again exposed, and even the absorbent powers of the stone itself contribute to this action. It therefore becomes necessary to repeat the painting frequently, and thus, in the end the delicacy of any mouldings or carving must be effaced. The unequal rates of expansion of the stone and of the oil paints in time of frost tend to increase the danger of irregular and unequal exposure above attributed to the evaporation of the oil.

2nd. As to the injection of oleaginous, fatty, or waxy matters, it must be evident that it likewise can only act mechanically by closing the pores of the stones; and therefore, although instances may be cited in which when the surface so protected is maintained at a constant moderate temperature, the system of injecting those materials has succeeded, yet, if the protected surfaces be exposed to extremes of heat and cold, the heterogeneous materials thus affected must be acted upon in very different manners. Experience has confirmed this theoretical inference, and it has been found in practice that the protecting coats of any of the materials alluded to are gradually detached from the stone, and that they require to be renewed quite as frequently as oil painting itself does when used on the exterior of buildings.

3rd. One of the most successful attempts yet made to prevent the decay of soft building stones, by washing their exposed faces with a fluid able to affect their nature, is the process lately introduced by M. Kuhlmann,* in which the carbonates of lime are washed with a solution of an alkaline silicate, with a view to converting them into silicates of lime through the elective affinities of the lime and the silica. In some cases this ingenious and beautiful system has succeeded, and very great hardness and great resisting powers have been communicated to the stones operated upon. But unfortunately the action of the silicic acid is a very slow one; and when the surfaces washed in the manner described are exposed to rain, it is by no means rare to find that the solution is carried away. There is another very serious objection to the use of the simple alkaline silicates, namely, that when they do act upon the subjacent stone, the soda and potassa (which are generally used) are left free, and in effloresing they are likely to carry away the finer details of the sculpture or moulding; at the same time, as they form to some extent deliquescent salts upon the face of the stone, they attract to it a dangerous amount of humidity.

4th. The problem of protecting the surface of a soft building stone, after every precaution has been taken, be it observed, to prevent the internal absorption of moisture, seems to me to have been the most successfully solved by Ransome's last patent process. In this process, a fine precipitate, clothing the whole of the pores of the surface of the stone, is produced, by first cleaning the stone carefully from dust or other extraneous matters; then the stone is made to absorb as large a quantity as possible of the silicate of soda or of potassa, and when this solution has dried into the stone a second wash is applied, consisting of the chloride of calcium or of baryta. In practice Mr. Ransome uses the most frequently the silicate of soda and the chloride of calcium; and the effect of the respective applications is, that a double decomposition takes place in the washes, giving rise to the precipitation of a finely crystallised silicate of lime or of baryta in the pores of the stone, and an efflorescence of extremely soluble salts of the chlorides of soda or of potassa. The former remain in the pores,

* See Journal, vol. xxii. p. 276.

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the latter are speedily washed away by rain. As the rate of contraction and expansion of the silicate of lime is, as nearly as may be, the same as that of the stones it is intended to protect, there is no danger of the precipitate being detached by this cause. It may be added that Kuhlmann's process is only applicable to the preservation of the carbonates of lime, whilst Ransome's process is equally applicable to that class of materials, or to the sandstones, or even to bricks, or plaster, or cement. It was precisely to this process also that I referred when speaking of the use of chalk as a building material, and I am convinced that by its application that abundant and economical substance might be very advantageously applied to our daily wants.

Perhaps it is going a little beyond our immediate subject, but I cannot refrain from saying that the principle of the double decomposition applied by Ransome to stones might be applied to the precipitation of a soluble glass upon woods or textile substances, and even to the protection of timber from the attacks of boring worms.

Finally I repeat what I have said elsewhere, namely, that the common sense of the whole matter is to use only such stones as have been proved by secular experience in the locality of the building to be little exposed to decay. I use the term "secular experience," because the commission appointed to select the building stone for the Houses of Parliament recommended an untried stone, mainly upon faith in the indication of Brard's test, which had even in those days been seriously challenged. The consequences of this unfortunate error are now notorious, and it is worthy of remark that the newest parts of the Houses of Parliament, viz. the west front, are precisely those which are the most seriously affected.

There are however many economical and constructive reasons for resorting occasionally to the use of soft, easily worked, and as such almost always perishable stones. In such cases those stones must be isolated from ground or other damps as effectually as possible, and their exposed surfaces covered at once with an efficient protecting coat, before the process of saltpetreing can commence, and I believe that Ransome's process is the best which has been yet presented to the public for this purpose. Whatever process may be adopted for protecting the surfaces of soft stone, it is moreover necessary to pay attention to the constructive law of laying them upon their true bed, and also to protect the more exposed portions of the work by covering them with harder, more resisting, and impermeable materials. Even the latter materials themselves are at times exposed to decay between wind and water, and therefore every possible precaution should be observed to limit the range of the absorptive powers of the stones —the first and foremost precaution for basement works being to establish an effective drainage all round the building, at such a distance from it as to prevent the capillary action of the stones themselves from obtaining any supply of moisture from the ground. In the upper parts of a building it is equally essential to prevent the rain from lodging upon any portions of the stonework, especially when absorptive stones are used above projections likely to arrest falling water.

In the *Discussion* which followed—

Mr. GODWIN said no one could walk through the thoroughfares of the metropolis, or any other large city, without observing the remarkable effect which time had had upon nearly all our modern buildings. It was of the utmost consequence, not only that the public should fully feel the necessity of selecting a good stone in the first instance, but that if possible some means of indurating the softer stones, which we were driven by economy to use, should be discovered. He was not certain whether the expression which Mr. Burnell made use of, that the decay of the stone in the Houses of Parliament was very painful, not to say shameful, was quite justified, because he rather thought Mr. Burnell considered it more easy to distinguish between a good stone and a bad stone than most persons found it in practice to be. His impression was —and it was borne out by the opinions of many practical men— that when a stone was once out of the quarry, it was almost impossible to say whether it was a good stone or a bad one. It would perhaps have been well if Mr. Burnell had dwelt to a greater extent on the numerous varieties of Bath stone, because that stone when taken from some quarries stood very well, whilst that from other localities not far distant would not answer for external work in England—certainly not in large towns. Touching the Caen stone, it was clear that much of it was really good; but the conduct of the Caen stone quarry owners seemed to him to be of the most suicidal character. Not many years ago, having occasion to use Caen stone in large quantities (although he had not himself recommended it), he visited the quarries in company with Mr. C. H. Smith, and they then made an examination into the condition of the beds. As many of them knew now, although it was not so well-known then, more than one of the beds of that stone were notoriously bad. It would not stand when exposed externally. Those beds yielded much larger blocks; they were easily worked; and they offered great temptations to builders; and consequently this inferior quality was sent to London and other places indiscriminately with the good stone. Mr. Smith and himself called together some of the quarry owners, and suggested to them that they should mark the stone from the soft beds, so that it might only be employed internally, and if it was used externally the fault would be the builders'. Only one firm would promise to do that. The other quarry owners said, "What are we to do with it? Some persons think it is the best stone. We must send it wherever they will have it." The announcement that that one firm had made the promise had had the effect of increasing their business; but whether they had ceased to carry out that suggestion, or whether the amount of bad stone sent was so much larger than the better qualities, certainly the Caen stone which was sent to this country could not now be depended upon, and ought not to be used for external work. He had himself been grievously disappointed with it, and should fear under ordinary circumstances to use it. With regard to Buckingham Palace, where Caen stone was used, that was perhaps the most remarkable failure that ever was witnessed. He recollected seeing the new front of that palace about a year or a year and a half after it was finished, and he found many parts in a state of perfect ruin. Large masses of stone were in the habit of falling from the cornices, and the result was the necessity of knocking off vast portions of the decorations, and making them good with cement, painting them several times, with a frequent necessity for repeating that costly process. The late Mr. Thomas Cubitt felt this most acutely, and he (Mr. Godwin) alluded to it rather in justice to the memory of that gentleman, who was not to blame in the matter. The circumstance affected him deeply, although he had not determined upon the use of the Caen stone, and had employed every means to obtain it of good quality. Touching those processes which had been brought before the public from time to time to harden this and other descriptions of stone, only one or two were now at all spoken of—only one, he believed, besides the two mentioned by Mr. Burnell. He had watched with considerable interest the application of Ransome's process, especially in the case of the chapel in Bloomsbury; and he should be delighted to find, when sufficient time had elapsed to enable them to judge properly, that it had the effect which theoretically they might justly look for.

Professor ANSTED said he had taken considerable interest in the subject of building materials, and the decay and preservation of them. He would say but little with regard to the materials themselves,—so many of which had been described in the paper, although some had been left undescribed, more particularly some varieties of English stone. The variations in the Bath stone were very remarkable. He proposed to confine his remarks to the two points—the cause of decay, and the means of preservation. Mr. Burnell had remarked that the decay of granite arose from the decomposition of the felspar which it contained. There could be no doubt that those felspars which contained soda generally decomposed, whereas those which contained potash did not. There were however exceptional cases, arising from peculiar conditions of hardness, which effected all crystalline stones in a remarkable degree; but here there was a doubt as to whether the conditions of hardness which exhibited themselves in the stone when taken out of the quarry were those which could be depended upon for future durability. He thought, generally speaking, those granites of which the felspar was hard and did not contain soda might be depended upon to last for an indefinite period, and that too without reference to climate. It was perhaps as little affected by climate as any stone. With regard to the causes of decay of limestones, they were to a great extent mechanical. Limestones must absorb more or less water. They always contained water. It was quite impossible, under any circumstances to get limestones that did not contain water; but all limestones that were used for building were decomposed partly mechanically and partly chemically. These stones were partly crystalline, and this often caused an irregularity. Some of the

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colite limestones were so variable in their character that no one stone could be taken as a sample of the rest. In other cases the crystallisation had gone on more regularly; there was more evenness in the condition of the stone, and the decay would not be so irregular; but still there was in all the limestones used in England—whether those of our own country or those imported—a great amount of irregularity in the grain and in the amount of absorption. In this the great difficulty lay. The dolomite limestones, being partly composed of carbonate of lime and partly of carbonate of magnesia, were in a different state. Where the carbonate of lime prevailed the stone was apt to take a powdery character, and consisted of grains in a fine state of division, which were easily separated as soon as a mechanical change took place, and those were combined with more crystallised portions, which consisted principally of the carbonate of magnesia; it was one of that class of stones that was selected as being the best adapted for the construction of the Houses of Parliament. So long as those stones were crystallised they were the best stones that could be taken, and the specimens examined in the churches in the neighbourhood of the quarry selected went to prove this, but unfortunately the quarry from which the stone for the churches had been taken was not found to be in such a state as to supply so large a quantity as was required for the Houses of Parliament, and they were obliged to go to another quarry in the same neighbourhood, which was not of the same quality of stone as that which had been experimented upon by the commissioners. No doubt that was the correct history of the matter. With regard to the decay of sandstones, that arose chiefly from the cementing materials of the particles of sand; if the cementing material was pure carbonate of lime, or mixed with oxide of iron, it would undergo the same changes as other carbonates of lime would. It would be acted upon by moisture and the carbonic acid gas which prevailed in the atmosphere of large towns, and those causes must produce a certain amount of decomposition. One great danger arose from the stone not being put in such a position as to have the full benefit of its stratification. If this were done the stone would peel off, whereas this could not happen if it was laid bedwise, which was the only proper position in which a stone should be placed. Now as to the mode of preservation. It was easy to see that if a stone could be coated in such a way that moisture could not get into it, and providing there was no moisture in the stone already, the thing was done. But the difficulty was to manage this, and it arose from the fact that no paint, no substance that contained organic matter, could by possibility be long of any use. It might last for a time, but if it was capable of being acted upon by the atmosphere, and became oxidised, then after a time it failed: the surface peeled off, and the moisture got in. The moment the moisture got into the stone the mischief began, and the work of destruction would go on as much as if the stone had never been covered at all. The difficulty was to find some material which would form a permanent coating upon the stone, preventing the entrance of atmospheric moisture, and doing so in such a manner that it was not liable to decay from the atmospheric influences to which the stone was exposed. Those were not altogether mechanical, though to a great extent they were so; the chemical conditions must also be carefully considered when the materials of the stone or the particles with which the grains of the stone were cemented together were exposed to the action of the atmosphere. The injurious atmospheric influences consisted partly of carbonic acid gas and partly of sulphurous acid—ultimately sulphuric acid in a diluted form; and there were other substances present in the air which had not yet been sufficiently examined. Those were enough to injure by dissolving the material of which the stone was composed. Now came the question of the irregularity of the grain of the stone. The moisture would eat away the more granular parts of the stone faster than the other parts, and by the capillary attraction between the grains of most stones, the moisture containing the acids would be absorbed through the crevices into the stone to some depth, and there would do its work till it produced a larger crevice, and made way for the water to act in a more direct form, and then with the temperature of the moisture below 32 degrees, it expanded until the water took a solid form, and disintegration ensued. Then came the question—How was this to be prevented? The old method adopted with stones and cement was to paint them, but that would only do under certain circumstances. It was an expensive process, and was unfitted for large public buildings. The next thing was to find some material which would form a coating upon the surface of the stone, and prevent the absorption of moisture. That had been tried over and over again. Kuhlmann's process, although very ingenious, was not a modern one. Kuhlmann believed that by washing the surface of the stone, or soaking into the substance of the stone a solution of silicate of potash or soda, or "waterglass," as he termed it, a permanent surface could be produced without much difficulty;—Kuhlmann believed that by putting in that solution of silicate of potash he should produce a chemical change in the limestone, and form a siliceous carbonate, or perhaps a silicate of lime. As far as the silicate was concerned it would only be in a granular form. When silicate in this form was produced, it was deposited in detached grains, therefore he feared but little good would result from this process. It was true that it succeeded by a slow process of change in a dry atmosphere in obtaining a hard and durable surface; and he thought that perhaps when this process was carefully adopted—when the material from which the soluble silicate was made was pure, and the operation was carried out in a dry atmosphere—it might be successful, but it was clear that that method could not be adopted in any building in our own climate. It had been tried in the less humid atmosphere of France, and failed, and if it failed in France it would do so more rapidly in England, because the climate of the former country was better adapted to help forward the process. Mr. Ransome had re-invented Kuhlmann's manufacture of soluble glass. Mr. Ransome tried the same experiments and found them fail, and then it suggested itself to him whether after all he could not produce an effectual process which should be independent of the dryness of the atmosphere; and, by combining the first wash of the soluble glass with a subsequent wash of chloride of calcium, he seemed to have succeeded—theoretically he had been no doubt successful. The double decomposition took place immediately, and the result would of course be the formation of a chloride of sodium and silicate of lime. What was the silicate of lime? They had only to look at the specimens of mortar which they found in old buildings to see the effect of this silicate of lime deposit. The cause of that peculiar power of the mortar to attach different pieces of stone together was that the grains of sand which were made use of in mortar became coated with a silicate of lime, and the surface also to which the mortar was applied was coated in the same way; and this silicate of lime adhered so strongly to substances foreign to it, which it attached together, that practically the most perfect junction was effected; and when the mortar was very old the substance of the stones would separate more easily than the mortar. If they could deposit this thin film of silicate of lime they would do all that was required. In large quantities silicate of lime was not so available as in smaller quantities;—there was something in this thin film attaching itself to a foreign body: and it was the particles attaching so strongly to each other which produced the remarkable effect which was found in old mortar; but still no doubt time had something to do with it. The deposit of the thin film of silicate of lime he imagined was hardly in a crystallised state, but no doubt this deposit was the whole secret of the success. There could be no doubt but that the silicate of lime was deposited, for all who looked at that part of the Houses of Parliament which had been washed by Ransome's process, after having been exposed for four winters, would see how the case stood. It appeared that there was too much of the silicate put in, which had given an unsightly appearance to the stone. That however had been corrected since. The surface there was very distinctly coated with a substance which was so hard that he could not scratch it with a knife; and though there was considerable efflorescence upon the surface acted upon in this way, yet this could be washed off. The efflorescence came off easily from the whole surface; therefore, as far as the test of these four years was concerned, the results must be regarded as satisfactory. He believed there had been no efflorescence in the case of the chapel at Bloomsbury; and of the other cases he could not say more than that they had the appearance of being in a satisfactory state.

Mr. C. H. Smith said, with regard to the selection of magnesian limestones for the Houses of Parliament, he believed that if other parties had to conduct the same investigation over again, they would come to the same decision; but in this case no person was appointed to exercise a supervision or inspection of the stone as it was delivered from the quarry. They need not therefore be surprised that the quarrymen pushed in all the stone they had got; and there was a great temptation to use bad stone when there was nobody to object to it. The commission to which allusion had been made consisted of Sir Henry de la Beche, Dr.

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William Smith, Sir Charles Barry, and himself, and they were occasionally assisted in their investigations by Dr. Buckland and Prof. Phillips, and in the chemical department by Professors Daniell and Wheatstone. Seeing there was no supervision of the stone as it was delivered for use, his only surprise was that things were not worse than they were. As examples of the same description of stone, he might mention the Museum of Practical Geology, in Jermyn-street, in which there was scarcely a bad stone; also the offices of the Amicable Life Assurance Company, in Fleet-street. The latter building was finished within about seven months after the return of the travelling commission, and in the stone of that structure there was scarcely a trace of decay; indeed, it was sent from the quarry as a specimen of the best to be found there. When the defective state of the stone used in the new buildings in Lincoln's-inn was discovered, he, having been at that time sent by the government to see whether the quarries were being worked well, took the opportunity of inquiring where the stone used at Lincoln's-inn came from, and he was taken to two particular beds. Upon putting his finger upon the stone that was then being quarried it left an impression, which showed the stone to be in a state of decay even while in the quarry; and the reply to his inquiry, how that stone came to be used, was that the builder would not have any other, because it yielded him the largest profit. Mention had been made of the decay of granite. He believed that was occasioned by the decomposition of the felspar, and this was evidenced by the enormous beds of sandstone in which there were the grains of sand, the plates of mica, and the clay, which he thought indicated the decomposition of the felspar of the granite. With reference to the Portland stone, he considered it was one of the finest in the world, and owing to the facilities for water carriage was well situated for the London market and England generally. Previously to the decision being given as to the description of stone for the Houses of Parliament, there was some doubt expressed whether the merchants would be able to supply a sufficient quantity of Portland stone for these buildings, and it happened that at the same time Sir Charles Barry was about to build the Reform Club-house in Pall-Mall. For this building Portland stone was selected, and as the decision with regard to the Houses of Parliament was then doubtful, the quarry proprietors naturally supplied the best for this club, wishing to gain for it a favourable reputation. He did not think there was a bad stone in the whole structure, and though exposed to three different aspects for upwards of twenty years, it had stood perfectly. It seemed to have been a mania of late years for architects to use soft stone, and spend large sums of money to preserve it from decay, which in the end cost as much as if the best stone was used. With reference to the Caen stone, Mr. Burnell had alluded to Mr. Hope's mansion in Piccadilly. Mr. Smith thought that was one of the best specimens of Caen stone to be found in London, and that it had stood well. The chief cause of defective stone being used rested with the architects. A young architect would like to make as much display as he could for little money. To make a great show he used a cheap description of stone. It was generally put into the contract that the best materials only should be used, but it might be a question whether young architects, or even old practitioners, knew what was really good stone, and they would not apply to those who did. The builder naturally preferred a soft stone, because it was easily worked and yielded him the largest profit. With reference to the bedding of stone, allusion had been made to a remark which had fallen from him some years ago, that it did not matter which way the stone was put into its bed. What he stated was, that sandstones would be sure to decay if they were placed (as he had seen Cragleith stones) edgewise, because that stone would always more or less laminate: but with regard to oolitic stones he thought the most experienced in such matters could not say which way the bed was. With reference to the effect of sea air, and salts and alkalies upon stone, he would remark that sea air was not injurious to good stone, and bad stone would decay put it where they would. An extraordinary specimen of the Portland stone exposed to the sea air was to be found in Sandysfoot Castle, near Weymouth, which had stood since the time of Henry VIII., and at every storm and high tide was washed by the spray, and yet that structure externally was as perfect as ever. Mr Smith mentioned the results of some experiments he had made with limestone, by exposing it to the most violent tests of alkalies and salts, much more severe than any that could act in nature, and, as he showed by specimens, hardly any perceptible effect had been thus produced. In coating stone with any of the preparations named for preserving it, the great difficulty was to get the preservative material deep enough into the stone to be of use. If it was put merely upon the surface he considered it would have an almost injurious effect. If it did not penetrate deep enough into the stone to be beyond the influence of wet, the stone would come off in sheets. He had observed that in both the Conservative and Carlton club-houses, all the projections were not protected from the wet by lead or slates; he had, however, advised the architect of Mr. Hope's mansion to avoid that error, and the result had been that none of the projections of the building exhibited any symptoms of decay. An immense number of patents had been taken out for the preservation of stone from decay, but, as far as his own knowledge and experience went, the process of Mr. Ransome appeared to possess an advantage over all others. He had strongly advised Mr. Ransome to afford such a public test of his process as would by comparison place the question beyond all doubt; and this had been done, by coating half the surface of a stone which was admitted to be in a state of decay. The effect of the process could thus be rigorously tested.

Mr. Robert Hunt was desirous of correcting what he considered to be an error into which the author of the paper, Prof. Ansted, and Mr. Smith had fallen with respect to the decay of granite. It had been stated as the opinion of those gentlemen, that the disintegration of granite was due to the decomposition of the felspar. He was prepared to maintain that it was not due to that cause. Mr. Smith had stated that the china clay was produced by the decomposition of the felspar with the granite, and that this was going on at the present time. He was prepared to prove that the china clay, so far as human observation could go, never was true granite; and also, that atmospheric decomposition acting upon felspar had never gone to the depth of 300 feet, at which depth they found finer china clay than they did nearer the surface. He could take them over miles of country strewed with felspar;—the quartz was gone, but the felspar remained. Passing from that subject, they had entered upon the consideration of the means by which the decomposition of the ordinary sandstone was effected. Let them see what were the conditions. If they examined the old abbeys and churches they found stones which were taken from quarries now in use, upon which the marks of the tools of the workmen made 800 years ago were still perfect; and yet they found stone from the same quarries, when taken to London, Liverpool, Manchester, and elsewhere, in a short time showing a lamentable decay. Let them ask themselves how that arose? There appeared to be one set of circumstances which had been overlooked by those who had been called upon practically to attend to the matter. They must remember that in all large towns an atmosphere was produced which was more or less impregnated with gaseous exhalations, and they found the water—the dew and the rain—impregnated with sulphate of ammonia and carbonic acid. If they took any porous body—sandstone, or any body analogous to it—as had been shown by the investigations of Prof. Graham, they found that it had extraordinary powers of absorbing within its pores gases which were brought into contact with it. Moreover, if they took any of those sandstones and used them as a filter, and passed through them water impregnated with any of those salts or gases, and tested the water after it had passed through, they would find that by the mere mechanical action of the pores, those salts and gases had become separated from the water, and were retained in the stone, and by-and-bye chemical action gave rise to a decomposition which was constantly being noticed. A careful series of experiments in this direction would be very important. Discussion was comparatively of little value. It was the porous condition of the stone which they had to deal with. The great question to be decided was, how they were to prevent that extraordinary porosity? His attention had been called during the last two or three years to Ransome's process. It appeared to him more satisfactory than any other he had met with. There they had a silicate of potash applied to the stone, the surface of which had been rendered as clean as possible. The result was absorption. They then applied to the surface ordinary muriate of lime, which penetrated within the stone by two different actions, the one being the force of capillary attraction, and the other of chemical affinity. Chloride of potassium and silicate of lime were formed; the one being soluble was removed by rain, and the other remained to fill the pores. The great success of this operation, which after all could only be decided after a lapse of years, depended upon the fact that by filling up the pores with

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this silicate of lime, they prevented the osmose action going on within the pores of the stone.

Prof. TENNANT remarked, that it appeared to him that architects ought not to confine themselves to the stones already used, but in a country like England, intersected by railways in every direction, they might get a supply of new materials. It was only prejudice which caused people to adhere to the old system. He was acquainted with numerous limestones that might be worked at small cost and brought into the market; but when he had spoken to parties on the subject, the reply was that architects would only use those stones which had already been introduced, nor would builders use any other. But with the railways intersecting the country they were not left to the system which obtained at the time the old cathedrals were built. There were no railways or canals then. If they looked into any old encyclopædia they would find that the cost of conveyance from London to Windsor was put at the small charge of £3. 10*s.* per ton, in consequence of the canal that was made. A ton of goods would now be conveyed the same distance for a few shillings, and in as many hours as it before occupied days. His own experience convinced him that there was no place where they used worse building materials than in London, both bricks and stone.

ON THE INCREASED DEFLECTION OF GIRDERS OR BRIDGES EXPOSED TO THE TRANSVERSE STRAIN OF A RAPIDLY PASSING LOAD.*

By ROBERT MALLET, C.E.

THE fact of such increased deflection was established long since by the experiments of Captains James and Galton, R.E., and by Prof. Willis, in connection with the Commission of Inquiry as to the use of iron in railway structures; and the latter gentleman has founded some elaborate investigations upon the results, but of a character too abstruse to be of much practical application. To M. Morin, the author of so many important investigations in physics, seems to belong the credit of having first pointed out in a clear and distinct manner the true cause of the phenomenon, and by a rigid discussion of the English experiments with theory, proved the entire trustworthiness of the latter, as well as the general correctness of his own views. M. Morin has shown that in any beam or girder, or any bridge whatever, in which any deflection however small is produced by the transverse strain of a stationary load at the centre or other point of its length, the same load will produce a still greater deflection if transferred rapidly from end to end of the girder;—that this increase of deflection is due to centrifugal force, the path in space of the moving body being not in a right line, but in a curve concave towards the earth; and that the increase is greater as the original statical deflection is greater. In the case of a body constrained to move in a circle, and exposed to a tangential force, the centrifugal force f, or that in the normal, is

$$f=\frac{v^2}{\rho} \quad \ldots \quad \ldots \quad \ldots \quad \ldots (1)$$

ρ being the radius, substituting the height due to v^2,

$$f=\frac{2gh}{\rho} \quad \ldots \quad \ldots \quad \ldots (2)$$

and in relation to the force of gravity, dividing both sides by g,

$$\frac{f}{g}=\frac{2h}{\rho}$$

For these we may substitute the expressions

$$f=\frac{mV^2}{\rho}=\frac{P}{g}\frac{V^2}{\rho} \quad \ldots \quad \ldots \quad \ldots (3)$$

To connect this with the case of a moving load constrained by a curved surface, of which any small portion may be viewed as a circle—the elastic curve not differing th is sensibly from it—we require the value of ρ for the static or fixed load, and the centrifugal force f in terms of it.

Poncelet has shown that in the case of any beam fixed at one end, and exposed to a strain perpendicular to its length at the other end.

$$\rho=\frac{\epsilon I}{PC} \quad \ldots \quad \ldots \quad \ldots (4)$$

ϵ being the coefficient of elasticity of the material, I the moment of inertia of the beam, P the load or strain, and C the length of the beam.

But from the usual equation, the deflection of a beam supported at both ends, and loaded in the middle, is

$$\phi=\tfrac{1}{3}\frac{PC^3}{\epsilon I} \text{ from which we obtain } \frac{\epsilon I}{PC}=\frac{C^2}{3\phi}$$

and substituting this in equation (4) we obtain the very simple expression for the radius of curvature due to the deflection,

$$\rho=\frac{C^2}{3\phi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots (5)$$

which shows that, whatever be the transverse section of the beam, the radius of elastic curvature is equal to the square of half its length divided by three times the static deflection at the centre.

Now, as neglecting the weight of the beam in relation to the passing load, the centrifugal force f is given by equation (3) $=\frac{Pv^2}{g\rho}$; and substituting therein the value of ρ in equation (5), the expression for the force in the normal becomes

$$f=\frac{Pv^2}{g\rho}=\frac{3v^2}{gC^2}P\phi \quad \ldots \quad \ldots \quad \ldots (6)$$

But P=the static or stationary load; hence the total effort of the same load in passing along the curved line of the beam is

$$F=P+\frac{3v^2}{gC^2}P\phi \quad \ldots \quad \ldots \quad \ldots (7)$$

M. Morin applies this equation to the discussion of the experiments at Portsmouth of James and Galton, in five extensive tables; and as in some of these experiments the velocity of the passing load was extended until fracture of the cast-iron beam took place, he shows that if the true cause of the increased deflection be centrifugal force, then in all cases of fracture the value of F above must exceed that of R, the mean coefficient of rupture due to transverse strain on cast-iron, which he takes at R= 32441000 kilo. (in accordance with the results of Mr. R. Stephenson's experiments), and on comparison he finds this actually to be the case, as well as a very strict coincidence between the experimental and calculated values of the other terms.

That the value of f is such as to be able easily to account for the facts, he illustrates by noticing that in some of the extreme velocities tried, f is greater than 2P, or the centrifugal force more than twice the static load;—and hence the same beam was broken under loads smaller and smaller as the velocity was increased.

The influence of centrifugal force therefore, as affecting horizontal structures exposed to rolling loads at high velocities, is in all cases incontestable; for in all cases with any fixed load, however applied (even the weight of the structure itself), there must be some deflection.

The other conditions which affect the result, and sometimes appear to mask it, are, the weight or inertia of the girder itself, and its length in relation to v; *i.e.* the time given for its bending under the rapidly passing load. This increased bending or deflection takes place during the passing of the load, and the effort producing it takes time to be transmitted to the beam: hence, the point of maximum deflection occurs not at the centre, but beyond it, in advance or in the direction of the passing load, and there it is that fracture occurs. When it occurs in several points apparently at once, the beam is broken in several places in such rapid succession that its parts have not time given to separate at observable intervals; perhaps this effect of the shortening of the time of action with increase of velocity explains why it is that in the experiments made the increment of deflection actually diminished in some cases in place of increasing beyond a given limit of velocity.

The practical conclusions to be deduced are not unimportant. It follows, that the stiffer and the more elastic any railway girder or other bridge is, the less its deflection with its own weight and any load at rest upon it, the smaller will be the disadvantage of the increased strain due to a load at high velocity passing over it.

That a high coefficient of elasticity, such as is obtained by the use of wrought-iron, is of much more value than great weight in the structure. The effect of the inertia of motion due to the latter being to aggregate the evils produced by the centrifugal force, although the primary effect of the inertia of rest must be to lessen the extent to which it can act in a given time of transit.

The equations (3, 6, and 7), showed that the increased pressure

* Paper read at the Institution of Civil Engineers of Ireland.

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of a given rolling load upon any girder bridge structure increases as the square of the velocity and inversely as the radius of curvature; so that the increased distress upon every structure along a line of way produced by the passage of an express train over that of a parliamentary train of equal weight and length is in round numbers about as four to one.

Where the total load is applied uniformly over the whole length of the girder at once, as when it is loaded with engines or carriages, first at rest and then rapidly run over, the effect of the increased deflection is greatly masked. For, first, the static deflection due to a uniform load is to that of the same load applied at the centre only as 5 : 8. Secondly, the normal force f acting always strictly in the direction of the radius ρ, when the girder is loaded all over at once, these forces at different points in a certain degree act against each other.

The views which have been thus enunciated also fully clear up the apparently contradictory phenomenon (which as a fact seems pretty well confirmed) that the experience of skaters shows them they can most safely traverse thin and unsafe ice at high velocities. Here the beam or plate is loaded at one point, but it is supported from below at all points by a fluid whose relative moment of inertia is enormous, and which requires a considerable time for its partial displacement. Moreover, the unloaded ice is an absolute plane,—there is no static deflection due to its own weight: hence the only deflection possible is what can take place during the momentary passage of the skater; and if he passed in an indefinitely short time there could be none at all.

Prof. Willis in his preliminary dissertation ('Application of Iron to Railway Structures') distinctly alludes to the phenomenon of increased flexure by rapidly passing loads, as one "in which the effects in question are analogous to the centrifugal action of bodies moving on curves," p. 187; and again alludes to this in pages 193, 212 and 213; but he nowhere very clearly enunciates the view that the question may be treated as a case of centrifugal force; nor attempts to do so. He endeavours to find the trajectory of the curve over the flexible beam from the differential equation of motion,

$$\frac{d^2y^2}{dx^2} = \frac{g}{V^2} - \frac{ga^4}{V^2S} \frac{y}{(2ax-x^2)^2}$$

in which x and y are an ordinate and abscissa of the curve, a= the half length of beam, S=the central static deflection, and V=the velocity of rolling load.

This equation by certain artifices Mr. Stokes has succeeded in integrating—reducing the constants to a single one, which he calls β, and whose value is

$$\beta = \frac{ga^2}{4V^2S}$$

and in this way Mr. Stokes has given solutions for the problem in its two extreme cases, namely, where the mass of the bridge is neglected with respect to the rolling load, and where the mass of the load is neglected with respect to that of the bridge.

Neither case however occurs in practice, the motion of the bridge itself, and that of the rolling load, being always mixed up in the total effect produced on the structure. As the constant β increases in value, the increment of rolling deflection in the first extreme case diminishes; and in the second of the two cases this increment is measured by the fraction $\frac{25}{8q}$ of S, the static deflection, the value of q being $= 2\pi\frac{\tau}{P}$ in which P is the period of one complete oscillation of the bridge from rest to rest, and τ the time in seconds that the rolling body takes to travel over the bridge.

Assuming then these fractions to represent the separate effect of the inertia of the bridge and of its load, and their sum the total effect, Prof. Willis calculates the increment of static deflection due to each in the case of certain of the experiments made; and finally calculates a table, in which such increments are given for each, and for both conjointly, on the supposition that the weight of the rolling load and that of the bridge are equal, a supposition not very far from the fact in many cases.

This table, "rough and empirical" as the distinguished author of the paper is content to term it, is sufficient to show that in some cases of practice the phenomena cannot be neglected, for that when the value of β is $=5$ the minimum tabulated, the increment of total deflection may more than equal the whole static deflection, which in short and weak bridges traversed at high velocities might be very serious.

The treatment of the whole subject by Prof. Willis is characterised by the clearness and ability that belong to all his works, but aiming at that perfection and generality that alone satisfies the desires of the mathematician, he has a good deal in his paper past the usual range of practical men, and by consequence his valuable investigations have been little studied by engineers, and seldom understood or fully mastered. This has greatly lessened the practical value of the results he has arrived at.

As the author of this paper found that doubts were expressed by some members of the institute at a former meeting, of the reality of the phenomena of increased deflection by rolling loads, and that the principles upon which the occurrence of such increased deflection in structures of whatever sort exposed to transverse strain and moving loads are proved to be inevitably necessary, did not appear generally known, he deemed that a brief notice in an elementary form might not be unacceptable.*

CIVIL ARCHITECTURE.

THE following is the substance of a lecture delivered by Mr. E. R. Denison at the South Kensington Museum, on February 22.

Mr. Denison said that the title which he had selected for his theme was not an ordinary one, and might not perhaps be quite clear to those who heard him. They had all no doubt heard of Gothic architecture, and Greek architecture, and Italian and Egyptian architecture, and of the five styles of Gothic, but not of Civil architecture as a style of architecture. They might have heard of Secular architecture and of Ecclesiastical architecture, but not perhaps of that which he ventured to call Civil architecture. The term might, like some things, be logically or historically wrong, but he ventured to think that it was justifiable, and had a meaning. He apprehended that the short and intelligible definition of "style" meant a mode of ornamental building that flourished at a particular time in a particular place. Until a recent period the various styles of architecture were successive. There was the Grecian, the Roman, the Gothic, and so on; but since the fall of Gothic architecture in the fifteenth or sixteenth century, what was commonly supposed to be a conflict of styles arose; though in reality there was no such conflict until a very recent time. Gothic architecture was supposed to have died out in the country. Then came the style of Sir Christopher Wren and of Inigo Jones, which is now called the Renaissance or Classic style. In early times there was no conflict of styles, although in the lapse of ages they might, so to speak, have once lapped each other; but still distinct traces were preserved of the Norman, the Pointed, and the English—there was no conflict. In the time of Wren there was no conflict, for Gothic was dead; Wren was too great a man and too profound a thinker to regard the Gothic with feelings other than those of respect, although his son, who might appropriately be termed the "Little Wren," subsequently spoke of it in a very different manner. The elder Wren instituted a style of his own, expanded the old classical models, and made up a style which was in a great measure his own, although he was not its founder, but merely its introducer—that style which was termed the "domical." While upon this subject he might remark that the dome with which we were all most familiar—that of St. Paul's Cathedral—was not a dome, but a cone. Sir Christopher Wren was not only a great architect but a great mechanic and astronomer, and if he had not been famous as an architect, his name would have come down to posterity as a great mechanic. He built the dome of St. Paul's in the shape of a cone, and he was quite right; for the only way to build a dome to carry a great weight upon it, was not to build a dome at all, but a cone, tying the bottom, as Sir Christopher Wren did St. Paul's, with a strong chain. This skilful treatment in respect to domes ought to be remembered to his credit. He was an inventor and expounder; he invented the Italian steeple, such as St. Bride's Church, Fleet-street; which however he (Mr. Denison) considered inferior to the Gothic steeple; but that was only a private opinion. Up to Sir Christopher Wren's time nothing was known in England of copying styles, or of a conflict of

* The reader's attention is directed to the highly important memoir which has appeared recently in the 7th vol., 5th series, of the 'Annales des Mines,' upon this subject, by Mr. M. E. Phillips, Eng. des Mines, intitled "Calcul de la résistance des poutres droites, telles que les ponts les rails de sous l'action d'une charge au mouvement."

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styles. After him came men of little note—Vanburgh and Chambers, of the former of whom a wit of his day had penned the epigram—

"Lie heavy on him, Earth, for he
Laid many a heavy load on thee."

Chambers was immortalized in that particularly lively-looking building, Somerset-house, in which the architect intended to construct a model Classic building, the windows of which were to be all large, and the corridors full of light! Leaping over another gap, we come to the end of the eighteenth century and beginning of the nineteenth, when there were no architects who would be long remembered in the annals of fame, although their works might stand for many centuries. This was the copying period—the Greek Temple style—an era of nothing but copies, and many of them bad copies too. How often, for instance, the Parthenon had been copied, upon all scales and in all materials, he would not pretend to guess. This was the epoch in which the London churches began to spring up in the form of Greek temples. The portico of Marylebone Church was a portico by act of parliament, and as such was entitled to be regarded with respect by all beholders. Then there was the Great Extinguisher church in Langham-place, with a round portico; the church of St. Mary, Bryanstone-square, with a semicircular portico at the side; and the new church of St. Pancras, distinguished for the money which it cost, and for its close resemblance to some heathen temple, the name of which he had forgotten. St. Pancras was built on the model of a pagan temple; it cost £100,000, and was to be remembered as a distinguished specimen of the church ecclesiastical style of the nineteenth century. But to thoroughly appreciate the utter badness of the copying style, it would be necessary to descend to modern times. In later times architecture seemed to have been set adrift. There was the Greek Temple style, the Wren style, and that of his followers and copyists. At that time no one had the idea that the Gothic style would be revived. At the beginning of the present century, for the first time in this country, there was no style of architecture, because there were so many styles. Gothic was supposed to have died out; the public had become tired of Greek temples; Wren had disappeared from the scene, and mankind was left to choose an architecture for themselves. Time was when the Gothic was spoken of in terms of disparagement, not by a prime minister who had set his face against it, but by a man of recognized authority and taste. In the latter part of the reign of the Stuarts, the last Catholic kings who sat upon the English throne, Evelyn described Gothic art as "fantastic and licentious"—as exhibiting "great industry in carving, but without beauty; dark, heavy, melancholy, and monkish." Then came the "Little Wren," who styled it, not indeed, "fantastic and licentious," but as "mountains of stone, not worthy of the name of architecture." Now, considering that the metropolitan cathedral occupied a larger area than any other building in the empire, a mountain of stone was about the last thing the son of Wren should have called a Gothic building.

The dawn of the revival made its appearance in a shape bordering upon the ludicrous: Horace Walpole's house at Strawberry-hill was the first specimen of Gothic revival. It was scarcely deserving the name of sham; in fact, it was such a sham that, compared to it the worst modern sham became a respectable reality. Having made a commencement at Strawberry-hill, it gradually crept into churches, and thus got on with quite as much success as the Greek or other ancient styles that came to be revived. There was now a choice of styles between the revived Greek and the revived Gothic. Then came the question—How was the choice to be made? One person said he liked this, another liked that; which was fair enough, for the estimate of art was gauged by taste, and not by reason. The object of temples, whether Christian or Pagan, it must be admitted, was the same, although the purpose to which they were dedicated was very different. That object was worship; and in order to worship it was deemed necessary to see and hear. The Greek temples were built to insure those objects as much as possible; and referring to that circumstance, Mr. Fergusson had pointed out a similarity which he had observed between Greek and Gothic models, in the manner in which the architects of each had endeavoured to obtain their light. If we were to choose the models of our churches upon logical grounds only, he saw no reason why we should not choose Greek temples. The houses of the ancient Greeks we could not however copy: first, because there were none of them left to copy; and secondly, because they would be unfitted to the climate in which we live. The Greek houses were built for a population living in 32 degrees of latitude, while we lived in 52; and while the Greeks required but little fire, such was our climate that we required fire and protection from the weather during the major portion of the year. Yet what was the fact; we did not copy Greek temples, and we did try to copy Greek houses. There was another peculiarity of southern buildings, and that was that they had porticoes, while we had cloisters—not cloisters for monks to read in, but cloisters to keep out the wind and the rain. Now, if we were in reality the practical people that we wished to be deemed, we would have copied cloisters, and not porticoes.

Mr. Denison next referred to town-halls, which, after churches, were growing into importance in proportion with the wealth and enterprise of the age. There were no town-halls in Greece or Rome, but on the continent they had been carried out in the Gothic style with great success. Among the principal town-halls built in England of late years were those of Liverpool, Leeds, and Halifax. These vied with each other in the costliness of their construction—a proof that even municipal bodies were not free from the vulgar crime of vanity. As municipal bodies were not the sort of communities likely to run into extravagancies of style, and as the town-halls of the continent were known to answer their purpose remarkably well, it might be supposed that they would be copied in this country. But they had not been. The Domical style had not been adopted, of course, but the municipal mind had run into an entirely opposite direction. There was no doubt some reason for this, and if they looked into history the mystery would be solved at once. Gothic churches were at first badly copied, but we improved as we went on, and we might now choose our own building—either the church in Margaret-street, or the Oxford Museum, or the chapel of Exeter College, at Oxford. Gothic architecture had now been applied to churches in great perfection. That it had succeeded was conceded, and it was now admitted that it ought to be extended to eleemosynary buildings, to colleges and hospitals, and even to workhouses, for which it had been found to be peculiarly adapted, both as regards the convenience of the inmates and the cost of construction. A writer upon architecture into whose book he had lately dipped, but whose name he would not disclose, had occasioned him some amusement by contending that Gothic architecture ought to be tolerated notwithstanding it had a character of its own—an archaic character, just as the Bible was continued, notwithstanding the archaism of the language. The archaism of the Bible and the Prayer Book! this was extremely good, as it was an admitted fact that the special prayers composed by bishops of the church for particular occasions were infinitely superior to those in the book of Common Prayer! But the Gothic was not the only style which had been badly copied. The Italian had been sinned against as much; and Downing College and the University Library, at Cambridge, were about the worst specimens of the Italian style which it had been his lot to behold. The Taylor building at Oxford was also a good specimen of bad Italian. It reminded him of a cherub, all head and wings—or rather, a small head, large wings, no body. Of Gothic however it might be said, that although there were many bad illustrations, it was working its way up. But he asked, how it happened that in the matter of town-halls the Gothic models of the continent had been wilfully rejected? The same Evelyn to whom he had referred, when speaking of what he termed "the great and noble buildings of the Greeks and Romans" had characterised their style as "pompous." Mr. Ruskin had also described it in similar terms, and he was inclined to believe that the pomposity of the Italian style was in accordance with the modern spirit of the age and of the municipal bodies who built town-halls. At Liverpool, where there were town dues from which the funds were drawn, £100,000 had been expended upon the town-hall, and the gates alone had cost £5000, including the luxury of a lawsuit; and yet, although the site was spacious and magnificent, the architect had not found it possible to put windows at both sides of his building. The town-hall at Leeds had cost a third of that at Liverpool, and yet nothing could be contrived to relieve the monotony of the sky-line but the superimposition of a wonderful tower—a tower which, he ventured to say, would evoke the wonder of Sir Christopher Wren, or of the builder of Canterbury Cathedral. At Halifax, where a town-hall was necessary because Leeds had got one, Gothic and Grecian plans were submitted for approval. The Gothic was rejected, and to the astonishment and horror of

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mankind, the corporation resolved to employ their own surveyor to build the town-hall. However, in the end wiser counsels prevailed: the surveyor was put aside, and the building was placed in the hands of an architect of great fame, whose name he would not mention.

But, notwithstanding the failures in public buildings, he thought it was gratifying to find that the taste for Gothic design was becoming every day more generalised, as evidenced by the improved taste exhibited in the Gothic villas in the neighbourhood of London. The Museum of Oxford was also an indication of a revival of Gothic architecture, for there, in his opinion, there was a great deal to admire (as for instance, the cloistered square, if the roof would fall in once more) and a good deal to blame; but still the portions that were good were very fine, and showed a hopeful tendency in the right direction. Another indication of the spirit of the age was to be traced in the Gothic roofs introduced so frequently in the designs for the new public offices lately exhibited in Westminster Hall,—these "abominable" high roofs were now forcing their way into Italian buildings. Carving was also extensively introduced, and many of the Gothic realities, including something more emphatic in the shape of towers. These latter were making their way into Classic buildings.

Mr. Denison next dwelt upon the necessity of paying attention to acoustics in the designing of buildings. Town-halls were for the most part intended for music and public meetings. It was therefore desirable that the science of acoustics should be applied to their construction; and yet the great halls at Liverpool and Leeds turned out lamentable failures in this respect. At Leeds there were under the same roof four smaller halls or courts for the administration of justice; and so lamentably had the acoustic properties been neglected, that you could scarcely hear yourself speak in them—the speaker was in fact bewildered with the echo of his own voice. Other buildings in Yorkshire were however more fortunate. Mr. Lockwood had built several which were most successful for the purposes intended. As a proof that the great hall at Liverpool was a failure as far as acoustics were concerned, he might mention that Mr. Cuningham had built another hall in the same town, because St. George's Hall was partially useless for the purpose for which it had been built. The chapel at Whitehall, which was cited as being so successful outside, was also sadly deficient in acoustic properties, although so much had been done to cure the defect.

Next, with regard to the choice of materials, he thought they ought to consider how buildings would look ten years hence, or a hundred years hence, and not how they would look the day they were finished. In his opinion, the only material that would look well, and at the same time bear the vicissitudes of our climate, was red brick, and not stone. He was also quite sure that it was a universal mistake to suppose that any style of architecture would be inaugurated in our day. His impression was that we would go on improving Classic, Gothic, and in fact all styles, and that no Victorian style or any universal style would meet with general acceptance.

COMPOUND COMPENSATED PENDULUM OF STEEL AND ZINC.*

By Mr. Lowe.

The author gave a short account of a compound compensating pendulum made at the suggestion of the late Rev. H. H. Jones. The rod of this pendulum was of wood, and the bob rested upon a zinc tube, which stood upon the regulating nut at the end of the rod. The zinc tube passed through a hole in the bob to its centre, so that the expansion or contraction of the zinc tube raised or lowered the centre of the bob, thereby avoiding the irregularities which arise from the expansion of the bob itself in other pendulums. As the bob is a large mass of metal, a change of temperature (which almost immediately expands or contracts the rod and the compensating tube) does not permeate it for several hours; but when suspended by its centre it is obvious that the change of length which takes place when it has arrived at its new temperature does not affect the rate of the clock, because it expands or contracts equally above and below its centre. If therefore the lengths of the pendulum rod and the compensating tube are correctly adjusted, the centre of the bob is kept constantly at the same distance from the point of suspension. The bob used in this pendulum and the one described hereafter are neither cylindrical nor lenticular shaped. They are about 10 inches long and 4 inches wide, with straight sides, and a transverse section would resemble a section of a lenticular bob; thus, the sides terminating in rather sharp edges, very little disturbance is caused in the air confined in the clock case.

Although pendulums made as above described have been tried and found to answer very well in dwelling-houses, they do not appear so well adapted to clocks in observatories. They have been tried at Mr. E. H. Greg's observatory, at Quarry Bank, and at Mr. Robert Worthington's, at Crumpsall, and irregularities were observed which seemed to arise from other causes than imperfect compensation. Although the wooden rods were carefully selected from dry and straight-grained deal, and protected from moisture by varnish, a change in the condition of the atmosphere from moist to dry, and *vice versâ*, was generally followed by a change of rate in the clock.

The author then determined to use steel instead of wood for the rods; and as a much greater length of zinc would be required to compensate for the expansion of steel than of wood, it would be inconvenient to place the centre of the bob upon the upper end of the zinc tube. The latter is, therefore, passed through the hole in the bob, its upper end being about 19 inches above the upper end of the bob; a brass collar is fixed upon it from which two steel rods descend (one on each side of the central pendulum rod); two holes are made from top to bottom of the bob to receive them, and they are secured half-way down by screws. Thus as the zinc expands or contracts it raises or lowers the centre of the bob as before described; or rather, a change of temperature which causes the zinc tube to expand upwards, causes the steel rods (which are all three suspended by their upper extremities) to expand downwards, and thus the centre of oscillation, which coincides very nearly with the centre of the bob, is kept constantly at one height.

As the centre of the bob of a pendulum to beat seconds of mean time in this latitude should be about 39·14 inches from the point of suspension, the following proportions were found by calculation for the component parts of this pendulum:—Length of central steel rod, from the bend of the spring to the bearing surface of the regulating nut, 45·37 inches; length of zinc tube, 30 inches; length of side rods, extending from top of zinc tube to centre of bob, 22·87 inches. The proportions of these lengths to one another were determined by the author from data found by experiments upon pieces cut from the steel rods and zinc tube of which the pendulum is made.

Objections had been made to the use of zinc, on the ground of the uncertainty of its ratio of expansion and contraction at different temperatures. It was therefore determined to construct an apparatus by which to ascertain whether this objection was valid. A considerable number of specimens of zinc were examined, but it was invariably found that they expanded with heat and contracted in cooling. Had there been any exceptions to the rule, they must have been detected, for an elongation of 1-50,000th of an inch was easily read off; and a tube of zinc, 4½ inches in length, could be observed from a temperature of 0° to 100° centigrade without removing it from the apparatus; and a change of 10° of temperature produced a change of more than 26 divisions of a scale, read off by means of a micrometer.

In the course of a series of experiments, made in conjunction with Prof. F. Crace Calvert, upon a number of other metals and alloys, and detailed in a paper recently read before the Royal Society, it was found that both zinc and steel have a very different ratio of expansion according as they are more or less crystalline in their texture.

Thus, a bar of zinc 2¾ inches long, cast horizontally, expanded for 100° centigrade 216·5; the same zinc cast vertically, having two axes of crystallization, 257·1; while the forged zinc tube expanded only 150·0.

The differences in steel are not so remarkable. The same length of steel at a maximum softness, 62·5; the same bar at a maximum hardness, 84·0; the same bar tempered so as to be malleable, 61·4. The steel rods used in a pendulum tested by Mr. Joseph Baxendell, in the observatory at Crumpsall, expanded 64; the zinc tube, 150.

It will be seen by calculation that 29·11 inches of zinc will expand sufficiently to compensate for the expansion of the steel rods, but an addition has to be made on account of a change which takes place in the elasticity of the pendulum spring. It

* Read at the Lit. and Phil Society.

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becomes weaker in heat and stronger in cold, and this has the same effect as a little increase or decrease in the length of the pendulum. No rule has, I believe, been laid down as to the exact amount of additional expansion of the zinc tube to compensate for this; but in former experiments with the pendulums with wooden rods about an inch was required to be added, and in this case 89-100ths of an inch seem to have had the desired effect.

The following is a copy of the rate of a clock at Mr. Worthington's observatory, fitted up with the pendulum above described.

Date.	Sidereal time.	Arc of vibration.	Clock error.	Daily rate.	Temperature in the interval.	
					Highest	Lowest
1860.	h m s	° ′	s	s	°	°
Jan. 11	2 12 54·8	2 27	5·8 slow			
14	2 25 59·8	2 32	11·0 ,,	+1·73	39·7	29·5
20	2 38 6·4	2 32	22·5 ,,	1·91	47	28
29	3 5 2·2	2 32	37·2 ,,	1·63	42	19·2
31	2 22 59·8	2 32	40·6 ,,	1·72	39	28·5

A small weight was then placed on the top of the bob, to change the rate, and the following results were observed:—

February 6th, 6h. 20m. 42·1s. to February 16th, 6h. 11m. 5·0s., with mean temperature of 29·1°, the daily rate = −0·67s.

February 16th, 6h. 11m. 5·0s. to February 28th, 6h. 45m. 21·6s., with mean temperature of 35·1°, the daily rate = −0·65s.

Extremes of temperature during the whole period: maximum = 44·5°; minimum = 16·5°.

FRYER'S APPARATUS FOR FILLING LOCOMOTIVE TENDERS WITH WATER.*

By J. Fenton.

(*With an Engraving.*)

Dr. Papin, the celebrated French precursor of the many inventions connected with modern steam power, demonstrated as early as the year 1700 the practicability of raising water by the direct action of steam pressure on its surface; and this system is still adopted with complete success for raising saccharine fluids in most sugar houses throughout the world. The method of filling locomotive tenders with water where the supply is below the level of the railway, recently invented by Mr. Alfred Fryer, of Manchester, and forming the subject of the present paper, is in fact an adaptation of Dr. Papin's simple contrivance of 160 years ago.

The apparatus is shown in Figs. 1 to 4, Plate XI. It consists of a wrought-iron cylinder A, of 1500 or 2000 gallons capacity, placed upright beneath the surface of the supply water B, Fig. 4, which may be from 10 to 120 feet below the level of the railway. To reduce the amount of condensation the cylinder A is surrounded with brickwork, and a space of 2 inches between the brickwork and the cylinder is filled with clay, to prevent any water from getting to the outside of the cylinder. The cylinder contains a wrought-iron float C, fitting it easily, and sliding on a centre guide rod. The supply water enters through the self-acting inlet valve D, Fig. 4, of about 75 square inches area, and is discharged from the bottom of the cylinder through the pipe E, leading to the engine water-crane F. A steam pipe G is attached to the top of the cylinder, leading to two pillars H, Fig. 1, placed a few yards distant on each side of the crane F, and near the line of rails, which are provided with flexible pipes I, having bayonet joints for coupling to the locomotive boiler. When a tender is drawn up to be filled, the engine driver couples one of the pipes I, to the boiler, as shown in Fig. 2, and turns on the steam, which, passing into the water cylinder A, presses on the float C, and forces the water up through the crane F into the tender, which is filled in about half the usual time.

In order to prevent the steam now contained in the upper part of the cylinder A from blowing out violently into the atmosphere when the flexible pipe I is disconnected, a valve is placed in the top of the pillar H, opening inwards, which allows a free passage for the steam to enter the cylinder, but when the pipe I is uncoupled, the steam can only escape slowly through a small hole drilled in the valve. A hanging valve K, Fig. 4, is placed between the two branches of the steam pipe G, which prevents the steam entering through one of the pillars H from blowing out direct through the other, instead of passing down into the cylinder A. As the steam escapes from the cylinder a fresh supply of water enters through the inlet valve D, the cylinder being placed below the surface of the supply water. The valve D is contained within a well L, and the supply water is admitted through the valve and grating M, by which it can be stopped back out of the well at any time to allow of examining the valve D; or the valve itself can be detached and drawn up to the top of the well, being slid down to its place upon long guide rods, and secured by long screwed bolts that can be reached from the surface. The float C is strengthened against collapsing by circular stays; and a small tube N is inserted into it, reaching almost to the bottom, so that if any water should get into the interior of the float through a defective joint, it is expelled through the tube as soon as the pressure of steam is removed from the outside of the float after filling a tender.

Fig. 3 shows the arrangement of the apparatus when the supply of water is obtained from a reservoir at the foot of an embankment; and the plan is equally applicable where the supply is taken from a well considerably below the level of the ground, or from running water.

In this plan of raising water by the direct action of steam pressure, it might be expected that the condensation of steam in the water cylinder would be so considerable as to interfere seriously with the working of the apparatus; but it must be borne in mind, that the larger the cylinder, the smaller is the extent of surface presented for condensation in proportion to its content; and it has been proved by experiment that this is not a serious objection in the size of the present apparatus; while the friction and waste of power involved with the pumps and engines now in use are obviously saved. In order to ascertain whether a locomotive boiler can afford to lose the amount of steam requisite to raise the water, especially where the lift is from 50 to 60 feet high, a boiler has been constructed of 141 gallons capacity, 69 per cent. of which was filled with water, connected by a flexible tube with a water cylinder holding 131 gallons, the arrangement being in all respects similar to that already described; the discharge water pipe from the cylinder rose 60 feet perpendicularly, but had valves at various lower elevations. The water pipe was 4 inches diameter inside, and the steam pipe 1½-inch diameter, and the area of steam way in the tap 1·83 square inch. A number of trials were made, in each of which 131 gallons of water were raised, the average height of lift being 52 feet, and the average pressure of steam in the boiler 56½ lb. per square inch: in order to guard against too rapid a generation of steam, and to approximate to the condition of a locomotive when standing at a station, the damper remained closed during each trial. It was then found that the loss of steam pressure in raising the 131 gallons of water 52 feet high was only 4·2 lb. per square inch, and the time required 32 seconds. When the damper remained open the steam was generated more rapidly than it was used, and the pressure then rose during each trial. Hence a locomotive just arrived at a station will always have sufficient steam to spare to refill the tender; and this will consequently be effected at the entire saving of the pumping engines, pumps, and buildings at present necessary, while the heavy expenses now incurred of attendance, repairs, and fuel are dispensed with.

With this apparatus there is no difficulty in working during frost, the crane and pipes being kept always empty, and the water cylinder below the ice; thus removing the danger of the pipes bursting, and obviating the necessity of keeping them thawed by the application of fires, as in the case of the present water cranes. This is a consideration of no little importance, especially in Canada and other countries subject to severe and protracted frosts. The steam that is condensed in forcing up the water is not entirely lost, as it serves slightly to warm the water which will shortly supply the boiler. It has been computed that the cost in fuel of raising 1000 gallons of water 50 feet high by this process is less than one halfpenny; and the plan is therefore recommended by economy, great simplicity, and rapidity of action.

After the reading of the paper,

Mr. A. Fryer said he had been led to this plan by difficulties experienced in raising continually large quantities of saccharine fluids, of a specific gravity of 1·3, which had to be raised a height of 60 feet to the top of the sugar manufactory. Cranes were previously used to lift the bags of rough sugar to the top of the

* Paper read at the Institution of Mechanical Engineers.

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building, but this was found to be a slow and expensive process when a large amount had to be conveyed; and pumps were then employed for the purpose; the first process of dissolving the sugar in hot water being performed at the bottom of the building, and the liquid then pumped up to the top. But the pumps were found to be rapidly worn and cut by the large quantity of sand, pieces of cane, and other rubbish that was mixed with the rough sugar, and no form of pump was able to stand the work. He then tried the direct application of the steam pressure to force up the liquid through a pipe, and found it so completely successful that the plan was adopted for the whole of the work. The dissolved sugar was put in a large close vessel, like a circular boiler, 6 feet diameter, with a delivery pipe 4 inches diameter extending from it to the top of the building, a height of 60 feet; and steam at 40 lb. per inch pressure was let into the upper part of the vessel, and pressing upon the surface of the liquid forced it instantly up the delivery pipe, the lower end of which reached to the bottom of the vessel inside. The process was effected with great rapidity, the solid refuse lying at the bottom of the vessel being swept clean out together with the liquid. A quantity of 20,000 gallons per day was regularly raised in this way, and the solid matter carried up besides amounted to several tons per day. The vessel was re-charged by condensing the steam in it by a jet of cold water upon the outside, and opening a communication with the vat in which the sugar was dissolved; the vessel then became rapidly filled, and the process of letting in the steam and expelling the contents up the delivery pipe was directly repeated. There was found to be but little waste of steam in this process, although no float was used in the vessel and the steam was admitted direct upon the surface of the liquid: for a film of boiling water was immediately formed upon the surface of the liquid by the condensation of a small portion of the steam, which acted effectually as a non-conducting diaphragm, cutting off the communication with the colder liquid below, since there was no circulation to convey the heat downwards.

He had also made a trial of the same plan for raising water from a well 65 feet deep upon the works, in which the pump was sometimes under water, so that the valves could not be reached for repairs, and the pump was consequently stopped working; and he had succeeded in raising 100,000 gallons of water per day by that means. In this case the rising main from the pumps, which was 18 inches diameter, had a second pipe 4 inches diameter inserted within it, extending nearly to the bottom and having a valve at the bottom opening upwards; the space between the two pipes was closed at the top with a steam-tight joint, and steam of 40 lb. pressure was admitted to it from an adjoining boiler. This steam expelled the water from the space between the pipes, driving it up the centre pipe; and on shutting off the steam a fresh supply of water entered this space by condensation of the steam, and was again expelled up the centre pipe by repeating the process.

In order to ascertain whether in the case of filling locomotive tenders there would be any risk of difficulty from want of sufficient steam in the engine boiler to serve for raising the water, he had tried some experiments with a small boiler disconnected from any other work, raising the water by the steam pressure from a close vessel up a vertical stand-pipe, which had cocks fixed into the side at different levels that could be opened successively for discharging the water. He found that the water was discharged at 60 feet height with a pressure of steam in the boiler of 27 lb. per square inch, which was only slightly above the pressure required to balance the column of water. The quantity of steam required was found to be so small that a supply of water sufficient to fill a locomotive tender was easily raised with the boiler fire checked and the damper kept closed, to correspond with the condition of a locomotive standing at a station. In applying this plan for filling tenders, his object was to employ the power available in the locomotive engine for raising the water direct, instead of requiring the erection of fixed pumping machinery and engine power at each station.

Mr. S. Bastow thought the plan possessed many advantages, and would be very suitable for the purpose intended; it had great simplicity and freedom from liability to derangement, which were important points in water supply for railway trains; and the security from damage and stoppage by frost would be a great gain: also the saving in first cost would be very considerable where stationary engines had now to be employed for pumping.

Mr. R. P. Williams had experienced much difficulty with the ordinary railway water cranes, which caused much trouble and expense in keeping them in working order. He was struck with the simplicity of the plan now described, and thought it would be a great advantage, and be very applicable for road stations, where the expense of working pumping engines was more particularly objectionable. The first cost must be much lessened by saving machinery and pumping engines, and there would be a great saving in the present cost of repairs and maintenance.

Mr. Fenton thought there would not be any practical difficulty in the working of the apparatus, and the locomotive engines would be sure always to have steam enough when on the line for raising their own supply of water. The plan would he thought be generally applicable, except at some terminal stations, where pumping would remain as at present; and the result would be a considerable saving in expense both of construction and of working.

ECONOMIC EFFECT DUE TO THE USE OF STEAM EXPANSIVELY.*

The second volume of Mr. Isherwood's very useful collection of Engineering Precedents for Steam Machinery, has lately been published, and quite equals the first in the interest of the examples and the experiments recorded. Among others is a paper, from which we quote, giving the particulars of experiments made with the Smithery engine and boiler, at the U.S. Navy Yard, New York, to determine the relative consumption of coal for the production of equal horse-power when using steam without expansion, and also with expansion, cutting off the steam at $\frac{22}{100}$ of the stroke from the commencement. The fuel used was Blackheath Anthracite, and it was burned both with the admission and without the admission of air through holes in the furnace door.

A comparison of the results obtained in the two cases of using the steam with and without expansion is given in the following table, and in separate columns for the results when the coal was burnt with and when without the admission of air through holes in the furnace door.

"The first thing in this table that requires notice is the great cost of an indicated horse-power in pounds of coal per hour; but if the conditions under which the Smithery engine worked be considered, this excessive cost can easily be accounted for. It is due to the high ratio which the back pressure bore to the total mean pressure, counting from zero; and to the low evaporative efficiency of the boiler.

In the first place the pressure required to overcome the friction of the engine and shafting *per se* was, as deduced from an extensive set of experiments, 2·5 pounds per square inch of piston. Taking for illustration the third column in the table, because the performance therein recorded is with expansion and without admission of air through holes in the furnace door, and therefore the nearest comparable with the usual conditions of practice; we find the mean gross effective pressure to have been 11·37 pounds per square inch, to which if we add the atmospheric pressure of 14·7 lb. per square inch, and the mean pressure of 0·8 lb. per square inch, above the atmosphere in the cylinder during the exhaust, we shall have for the total mean pressure during the stroke counting from zero (11·37+14·7+0·8=) 26·87 lb. per square inch, of which the back pressure and the pressure required to work the engine and shafting *per se* was (14·7+0·8+2·5=)18 lb. per square inch, or $\left(\frac{18\times100}{26\cdot87}=\right)$ 67 per centum, leaving only 33 per centum to be utilised; or out of a total mean pressure of 26·87 lb. only 8·87 lb. were usefully applied. The evaporation given by the boiler was the low one of 3·6035 lb. of water from a temperature of feed-water of 100° Fah. by 1 lb. of coal. Great therefore as was the cost (13·008 lb. of coal per hour) of the horse-power, it was only what might have been anticipated from the conditions; and it shows that not only were the proportions of the boiler very defective, but that the engine itself was greatly too large for the work to be performed.

The next thing that strikes us in the table referred to is the little difference in the cost of coal of a horse-power, when the steam is used without expansion, and when it is used with expansion, being cut off in the cylinder at 22 per centum of the

* 'Engineering Precedents for Steam Machinery.' By B. F. Isherwood, chief engineer, U.S. Navy. Vol. II. 8vo. New York: Bailliere, 1859.

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Table exhibiting the Comparative Results obtained from the Smithery Engine and Boiler at the New York Navy Yard, when using the steam without expansion and when using it expansively, suppressing its admission at $\frac{33}{100}$ of the stroke of piston from the commencement; the Fuel consumed being Blackheath Anthracite, burned both with and without the admission of air through holes in the furnace door.

	Steam used without Expansion.		Steam used Expansively.	
	Without admission of air.	With air admitted.	Without admission of air.	With air admitted.
Pressure in pounds per square inch above the atmosphere of the steam in the boiler	28·8	28·6	33	34·8
Pressure in pounds per square inch above the atmosphere of the steam in the cylinder at the commencement of the stroke	16·4	17·4	27·6	27·4
Pressure in pounds per square inch above the atmosphere of the steam in the cylinder at the point of cutting off	...	...	20·7	20·6
Pressure in pounds per square inch above the zero line, of the steam in the cylinder at the end of the stroke	24·1	24·5	14·8	14·7
Temperature in degrees Fah. of the air entering the ashpit (same as that of the boiler and engine room)...	63½	57	72	73
Mean gross effective pressure in pounds per square inch of piston ...	11·36	11·88	11·37	11·32
Mean number of double strokes per minute made by the piston ...	25·163	26 084	25·265	25·110
Gross horse-power developed by the engine (by indicator)	17·57	19·12	17·72	17·49
Pounds of coal consumed per hour	275·4	271·1	230·5	203·9
Per centum of waste of the coal in ashes, fine coal, &c.	19½	20	20	19$\frac{2}{10}$
Pounds of combustible consumed per hour	222·2	216·9	186·2	165·1
Pounds of water evaporated per pound of combustible, calculated from the pressure at the end of the stroke of piston, from the power developed by the engine, and from the heat employed to raise the temperature of the boiler water the difference of its temperatures at the commencement and end of the experiments	5·8495	6·2111	4·4592	4·9602
Pounds of coal consumed per hour per horse-power developed by the engine	15·6744	14·1789	13·0080	11·6581
Pounds of combustible consumed per hour per horse-power developed by the engine	12·6446	11·3442	10·5079	9·4403
Per centum of the total quantity of steam evaporated, according to the indicator, condensed in the production of the power developed by the engine	3·06	3·24	4·68	4·72

stroke of the piston from the commencement. The *theoretical* gain in fuel due to this measure of expansion over using the steam without expansion, is 1·515 times; that is to say, a given weight of steam when used with this measure of expansion ought, according to the law of Mariotte, to produce 1·515 times more indicated horse-power than when it is used without expansion. The first glance at the table shows that this gain has not, with the practical conditions under which the steam was used, been even remotely approximated.

The discrepancy between the theoretical prediction and the practical result, though enormous, may be accounted for by taking into consideration the facts which would naturally tend to modify the former in the direction of the latter, and determining their value.

In comparing the relative advantages of using steam with and without expansion, the weight of fuel consumed is taken as the measure of the cost, and the indicated horse-power developed as the measure of the effect produced. Now to what part of this fuel does the fact of expansion apply? Evidently only to that part which has produced the steam actually used expansively in the cylinder. Upon all the remaining portion of the fuel, be it as large or as small as it may, the use of steam expansively has no influence.

In the first place, taking the average of boilers, the fuel produces upon the water only about two-thirds of its calorific effect, owing to the losses of heat in the products of combustion entering the chimney, and to the imperfection of the combustion itself. Of the fuel too, a portion, probably 5 per centum, is lost in fine pieces falling unburned between the grate bars and in cleaning the fires. In marine engines there is also the further loss by 'blowing off and feeding in' to prevent the formation of scale, and the loss from this source is on an average in practice about one-sixth of the heat entering the boiler water: this of course includes the loss by 'priming,' as that forms in effect part of the boiler water to be extracted. Thus of the 100 per centum of the original fuel (33+5=) 38 is lost without imparting heat to the water, and of the remaining 62, one-sixth, or say 10 per centum, is lost by the 'blowing off,' leaving only (100−38+10=) 52 per centum, or say one-half, applied to the generation of steam. It is plain enough now, that any saving of fuel by the use of steam expansively can only be made upon that half of the total fuel consumed which is applied to the generation of steam. Upon the other half the fact of expansion has no influence, and this at once produces a practical reduction of one-half in the theoretical gain of fuel due to the measure of expansion employed for the steam. Of the steam however that is generated, but a portion produces a dynamic effect upon the piston, and it is to this portion only that the theoretical gain can be applied by using it expansively, and that gain will be practically greatly lessened by certain physical properties of the steam, and the conditions it is used under, all of which are ignored in the theoretical law of Mariotte.

The causes that prevent us from obtaining the full dynamical effect of the steam after it is generated, may be distributed under the four following heads, namely:—annihilation of the steam by condensation; the escape of steam by leakage; the resistance of the back pressure in the cylinder to the movement of the piston; steam used in filling the cylinder clearance and ports.

The first head may be subdivided into—1. Condensation of steam due to the conduction and radiation of heat from the exterior surfaces of the boiler, steam-pipe, valve-chest, and cylinder. 2. Condensation due to the difference between the temperatures of the interior surfaces of the cylinder, its valves and piston, during a double stroke of the piston. 3. Condensation due to the fact of the expansion of the steam *per se*. The leakage consists of the steam which, escaping past the valves and piston, passes to the condenser without producing any dynamical effect upon the piston. The back pressure opposing the movement of the piston is composed of the uncondensed vapour in the cylinder; to this pressure must be added in effect that which is required to work the engine and shafting *per se;* for it is evident that, like the back pressure, it must first be balanced before the piston can move. That portion of the steam which is used in filling the space between the face of the valve and the piston when at the end of its stroke (comprised in the cylinder clearance and ports), produces no dynamical effect upon the piston when the steam is used without expansion. When it is used expansively, some dynamical effect is obtained from the portion filling the clearance and ports; but the loss from this cause is, nevertheless, greater than when the steam is used without expansion.

We will examine in detail the above enumerated causes of loss of dynamical effect by the steam, and distinguish their values in the cases of using it with and without expansion.

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Of the condensation of steam due to the conduction and radiation of heat from the exterior surfaces of the boiler, steam-pipe, valve-chest and cylinder. It is impossible to estimate the amount of loss from this cause, but that it is considerable will be granted by all whose experience has enabled them to observe the quantity of water formed by the condensed steam in the pipe during a short time with the engine at rest. This condensation will be influenced as to its absolute amount by the thickness and conductibility of the metal, and by the clothing given to the surfaces; but with equality in these respects, it will be in the ratio of the surfaces and the difference of temperature of the steam within and the air without.

In comparing steam used with and without expansion, it may be done under two conditions, making the engine under both to develope equal powers in equal times, for the object is to ascertain for a given power the most economical mode of using steam. We may condition, 1. That the boiler pressure be the same in both cases, when the engine using the steam without expansion will employ a higher mean effective pressure per square inch of piston, will have much the smallest cylinder, and will lose the least by friction and back pressure, but the loss by radiation will be about the same. 2. That the same cylinder and mean effective pressure per square inch of piston be employed; in which case the boiler pressure will be much the highest with the expanded steam, and the loss by conduction and radiation from the exterior surfaces of the boiler, steam-pipe, and valve-chest, will be proportionately great; but the radiation from the exterior surfaces of the cylinder and the condensation by the interior surfaces will be about the same. The friction and back pressure losses will also be about equal; but the higher the pressure, and consequently the temperature of the steam in the boiler, the greater with marine engines will be the loss by 'blowing off and feeding in' to prevent the formation of scale; for the temperature of the feed water being constant, the higher the temperature of the blown-out water the greater will be the loss of heat from this source; besides which the concentration at which sea-water deposits scale lessens with increase of temperature, and a greater per-centum of 'blowing off' is then required, with, of course, a *pro rata* loss. The second are the conditions under which the experiments with the Smithery engine and boiler were made; but as in them the steam pressure in the boiler was carried nearly the same—the difference being only between 43·4 and 48 6 pounds per square inch, counting from zero, the equality of the mean effective pressure on the piston being obtained by excessive 'throttling'—the loss by radiation was very nearly equal; and as the boiler was supplied with fresh water, there was no loss in either case by 'blowing off;' neither was there any sensible priming.

Of the condensation of the steam due to the difference between the temperatures of the interior surfaces of the cylinder, its valve and piston, during a double stroke of the piston. It is assumed that the interior surfaces of the cylinder and the surfaces of its valve and piston, will have the temperature of the steam or vapour with which they are in contact: this temperature will vary during a double stroke of piston between the temperatures of the entering steam and of the exhaust; in fact, all the power of the engine—the latent heat apart—is due to their difference. Now, at the commencement of a stroke of the piston these surfaces will have the temperature of the vapour of the exhaust or back pressure in the cylinder to which they are then exposed; hence, when steam is admitted from the boiler it will strike surfaces having a temperature less than its own, and will suffer the condensation due to the difference. The absolute amount of this condensation will be in the ratio of the area of those surfaces, of the conductibility and specific heat of the metal, and of the difference between the mean temperatures of the steam during a stroke of piston and of the vapour constituting the back pressure against it; and it will be further increased by the humidity which, like a dew, covers the surfaces at each condensation, and exercises more influence even than the metal itself, whose capacity for heat is greatly less.

When the steam is used expansively, a small portion of the dew or condensed steam deposited during the first portions of the stroke of the piston is doubtless reconverted into vapour under the lessened pressure of the expanded steam in the following portions, and exercises a useful pressure on the piston: this cannot be the effect in the case of steam used without expansion and of uniform pressure during the whole stroke, and so far as it goes makes the loss less by this condensation when using the steam expansively than when using it without expansion.

The condensation of steam in the cylinder due to the varying temperatures of its interior surfaces is inherent to its use, and cannot be prevented or modified by any external clothing or felting. The only means of prevention are to surround the cylinder with a jacket filled either with steam or with hot air, or to superheat the steam in the boiler, but they all produce the effect at the expense of fuel; an amount of heat equivalent to the refrigerating influence must be expended to counteract it, though it may be more economical to obtain that heat from the sources indicated than from normal steam in the cylinder. Whether it be or not, and to what degree, depends upon conditions too variable and exceptionable to be generalised here. The problem is whether the amount of heat thus expended in the last two cases could not be made to produce a greater economic effect upon the piston, if applied to the evaporation of more steam in the boiler. With boilers so proportioned that their heated gases are discharged into the chimney at too high a temperature for a good economic evaporation, there may undoubtedly be derived a gain by using a portion of the waste heat to superheat the steam, or to envelope the cylinder; this, however, is only a mode of recovering what ought never to have been lost, and will probably be found inexpedient, if carried far, on account of injury to the rubbing surfaces of the cylinder, now so well lubricated by the water of the condensed steam. The gain by the steam jacket is not so clear, though strongly insisted on by many, as the condensation of steam in the cylinder can only be prevented by the condensation of an equal weight in the jacket; and the annihilation of equal weights of steam is the loss of equal powers, let it take place where it may.

Of the condensation of the steam in the cylinder that results from the lowering of the temperature due to the fact of expansion per se. The instant the introduction of steam into the cylinder from the boiler is suppressed—the movement of the piston continuing—the steam expands, and its temperature falling simultaneously with the expansion, a condensation inevitably follows, and a part of the steam is precipitated in the form of water. A consequence of this condensation is a still further expansion of the steam (in addition to that which results from the continuous retreat of the piston) to fill the space due to the difference of the bulks of the steam before it was condensed and of the water resulting from that condensation; this second expansion is accompanied by a still further reduction of temperature, causing in its turn another condensation, which again gives rise to another expansion, and so on until the end of the stroke. As it is impossible to expand steam without reducing its temperature, this process of condensation, which is wholly irrespective of external refrigeration, is an inherent function of the steam, and becomes continuous after being once commenced; and will be the greater the greater the measure of expansion employed for the steam. It results from the fact that although the total heat of steam of higher pressure is greater than the total heat of steam of lower pressure, yet as the latent heat of the latter increases in a much higher ratio than its total heat diminishes, and as this increase in the latent heat is at the expense of the sensible heat, it becomes a cooling process, and produces the condensation stated.

As it is then impossible to expand steam without lowering its temperature, and as this lowering is inseparably accompanied by a condensation, and as these effects of the reducing of temperature and the precipitating of water after having once commenced, propagate themselves in a rapidly increasing or geometrical ratio, it follows that if any vessel filled with steam be a little enlarged so as to allow the within steam to expand, though ever so slightly, condensation produced by that expansion *per se* will instantaneously take place, and proceed with continuously increasing rapidity until all the steam be converted into water, and this without any aid from external cooling.

In estimating the gain to be derived from using steam expansively, a great error is made by supposing that the weight of steam passed into the cylinder is correctly measured by the indicator, and is per stroke of piston a cylinder full of steam of the pressure at the end of the stroke as shown by the instrument. Such however is not the case; the indicator does indeed measure correctly the weight of steam *discharged* from the cylinder at the end of the stroke, or the weight *present* in it at any point of the stroke, but not the weight of steam that has at the end or at any point of the stroke of the piston been *received* into the cylinder; for the indicator being simply a measurer of existing pressure, cannot, it is manifest, show the weight of steam that has been condensed in the cylinder by any cause whatever."

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BURFORD'S PANORAMA.

THE recent addition to this panorama is one of an unusually architectural character—Venice, which, though usually termed the "city of the sea," is here seen as a land-view from one of its most important positions, the piazza of St. Mark. In and about this spot are concentrated some of the most interesting buildings which that opulent city can boast; in the immediate foreground we have the gorgeous St. Mark's itself, with all its glow of marbles and painting giving intensity to the already noble portals and other bold features. Adjoining is part of the Doge's palace, now so well known by description and photographs innumerable. Next is a glimpse of the sea, interrupted by the columns of St. Mark, but revealing at a distance the church of San Giorgio. Returning again to nearer objects we have the lofty campanile of the *place*,—the imperial palace, whose architecture it is said suggested that of the new buildings in Paris,—the famous horologe with its astronomical clock, and the gaunt bronze figures on the summit which strike the hours:—and, to complete the circuit, the archbishop's palace, a poorly designed and most unecclesiastical-looking edifice. Scattered in the distance will be observed various domes, including the exquisite one of Sta. Maria della Salute;—several campaniles, and the beautiful church of SS. Giovanni è Paolo—the Westminster-abbey of Venice. The enumeration of these will sufficiently indicate that this panorama forms an interesting field of study for all, and the scale to which they are shown admits of much of the detail being expressed, so that it becomes doubly valuable to some, and it is for this reason that we bring the subject now before our readers. The general scene is supposed to occur during the carnival, and its many and varying incidents are introduced, serving much to heighten and enliven the general effect.

COLONIAL PATENT LAW.

By F. W. CAMPIN, F.S.A.

(*Continued from page* 92.)

As the British colonies are to a certain extent grouped togegether, those already brought under consideration in the last number of this Journal, the North American provinces, being perhaps the oldest and best established, similarity will be found to exist in the local laws and institutions in each of the colonies which is a member of the same group with those of its other colonies; Canada, in the case of these North American provinces, being the standard or basis; which observation will be found to hold good as regards the colonies now to pass under review, viz. the West Indian, the system here adopted being generally that of making patent grants by special or private bill or ordinance of the legislature, as will be seen from the following statement.

Jamaica.—By the island act 16 Vict. cap. 12, it is declared that no letters patent obtained in England or elsewhere shall be valid until declared so by an act of the legislature of this island, and such act must be sought for by petition to the legislature signed by the parties who are interested for the bill, and those who consent thereto, or by their legal representatives. In fact, a private bill must be passed granting patent privileges in this colony, and it is provided by the standing orders of the legislative body that before the bill can be entertained a specification of the objects of the invention must be duly recorded in the office of the secretary of the island, and certified copies produced to the legislature in due course. The fees payable on a single private bill to the officers of the legislature, that is the assembly and council, amount to £55. 1*s.*, but where there is more than one object they are double and treble, but no more; and in addition to this there would be the fees and expenses in the lawyer's office for preparing the necessary document, and these would depend on the length and intricacy of them.

Honduras.—Her majesty's superintendent reports, there is no local law of the settlement relating to patents, and that he cannot learn that any patent has ever been applied for or attempted to be exclusively exercised or restrained in this settlement.

Barbadoes.—Here also the only course open to a patentee appears to be to apply for a private bill in the local legislature, when it would appear necessary to file the specification and a copy of the British patent. As to fees the attorney-general reports that he is not aware that the mere application for a patent right would involve the payment of any official fees, but should the application be successful a private act would be passed, and the following expenses at the secretary's office would result:—a charge of 8*d.* per folio of ninety words for recording the patent and specification, and another of £3. 6*s.* 8*d.* upon the passing of the act; and he adds that the act being a private one is prepared by the clerk of the house of assembly, the charge of that officer is £3. 6*s.* 8*d.*

Grenada.—No law, and no rules of practice. The officer administering government reports that, since the right of granting a patent has been ceded to or been supposed to vest in the legislature of this colony, no application has been made for a patent, and no rules consequently have been laid down with regard to the documents to be required from an inventor to enable him to seek patent rights, and no statement of fees or expenses to be paid in such cases is in existence.

St. Vincent.—A private bill in the local legislature is required here also, but there are no rules or practice. The following are stated to be the official fees payable:—on recording a British patent, 7*d.* per folio to the registrar: on passing of a private act of the local legislature,—clerk of assembly £2; clerk of council £2; fee on great seal £5; attorney-general £10; government printer, according to length and number of copies. The attorney-general adds, "In addition to the foregoing there would, I presume, in the case of an act granting patent rights, be official charges on the specifications and various documents and proceedings on which the bill would be founded and brought in; but these would, I presume, be the subject of special allowance by the legislative bodies, as there is no law governing the question, or precedents to guide."

Tobago.—Mr. Solicitor-general Van Buren reports that there are no local statutes on the subject of patents, and that the practice and expenses in such matters is not settled; but he adds, that all documents coming from places beyond the colonial bounds must be attested by oath,—a declaration, as usual in England, will not do.

St. Lucia.—In this colony the patentee must apply for a special ordinance, similar to a private bill. The government expenses are not settled, but the attorney-general states that he should think that from £12 to £15 sterling would be a fair amount for the fees of that officer, in making the petition to the governor or legislative council, preparing the ordinance, &c., but this is not regulated by any tariff. No other fee would be payable, except some twelve shillings to the registrar of the colony, on filing at his office a specification of the invention.

Trinidad.—The form of procedure to obtain a patent hitherto pursued in this colony has been this: the party makes a petition to the legislative council, giving the name and purport of his invention, and on this an ordinance is passed, granting to him the exclusive benefit of his invention for a limited time, on condition that he lodges a specification before a certain day with the registrar-general of the island, and on condition also that if the invention is not a new one, or that it is prejudicial or inconvenient to her majesty's subjects, that the privileges granted to him shall cease. No fees are exacted either on the petition or the passing of the ordinance.

Leeward Islands.—The course adopted appears to be, to get a private bill passed through the legislature, on condition of the registration of such a specification as would be required for a like purpose in Great Britain. The fees are uncertain, but the following is a memorandum showing the fees usually payable on private bills:

Antigua.—No fees payable on patent granted in England. Chancery fees on letters patent granted under great seal of the island, £8;—By custom on private bills, £6. 15*s.*—to clerk of assembly, £14. 15*s.*

Dominica.—No fees established as payable in respect of patents either by law or custom.

Virgin Islands.—On letters patent under great seal of island, various fees, £18. 3*s.* 3*d.*

Nevis and Montserrat.—No fees established either by law or custom in respect of private bills or patent rights under the great seal.

St. Kitt's.—On private bill, fees about £13. 17*s.* 10*d.* No return as to patent under great seal not by legislative enactment.

British Guiana.—Patents, which were formerly for fourteen years, are now limited to seven years, and are granted by ordi-

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nances of the local legislature. There are no regulations as to the documents required from an inventor or British patentee to enable him to make a proper application for a patent right. The practice is for the applicant to present a petition to the governor and court of policy, stating in the most general terms the nature of his invention, and requesting the court to pass an ordinance in his favour. This petition, which is often unaccompanied by any documents whatever, is then referred by the court to the attorney-general to bring in a bill, which when introduced is treated in all its stages as a private bill, and clauses always are inserted requiring full and accurate specifications to be recorded in the registrar's office within six months after the passing of the ordinance, and providing that all privileges granted thereby shall cease and determine on any person disproving the originality of the invention.

Falkland Islands.—No colonial enactments have been made on this subject in these islands. In the present state of this colony there appears but little probability that any inventor or British patentee will think it worth his while to apply here for any exclusive privileges.

Eastern Colonies.

Mauritius.—The governor may, by ordinance No. 11 of 1835, accord letters patent for a period which shall not exceed fourteen years to such persons as may have invented or essentially improved any art or branch of industry in the colony, or who may be the first to introduce and put in practice in the colony any invention or improvement discovered elsewhere. Every means of adding a new degree of perfection to any manufacture whatever taken to be an invention. Patentees to pay a duty to be fixed by the governor, but not to exceed £100 sterling, according to the term of the patent and the importance of the invention. Patentees to have the exclusive faculty to employ the processes invented and to sell the produce thereof, also of prosecuting counterfeiters, and may obtain damages. In case of infringement, provisional seizure of the objects manufactured may be made: counterfeiters may in addition be made to pay a fine, not to exceed £200. An exact and detailed description must accompany the application for letters patent. Patents may be annulled for the following causes: for unfaithful description; for the reason that it has been ascertained that the object has been described previously to the issue thereof in a work printed or published; for non-exercise of privilege for the space of two years; or if a patent should be obtained for the same object in a foreign country after the date of the patent in the colony; or if the invention should appear to be dangerous.

Cape of Good Hope.—There are no patent laws or patent rights in this colony, but it is stated in the official report that a private act of the colonial parliament could be obtained to secure the patent right in any case when needed; and that the cost of such an act would not in this colony exceed £20.

Natal.—There are no laws recognizing patent rights in this colony.

NEW OFFICES OF THE METROPOLITAN BOARD OF WORKS, SPRING GARDENS.

SINCE the termination of the builders' strike the works of this edifice have progressed very rapidly, facilitated in a great measure by the use of bricks, mortar, and cement in the construction instead of stone, which system however, although it may aid in obtaining more ornate external display, can never be satisfactory, not being in accordance with the correct principles of good architecture. The structure is designed in the Italian style, and the various brick columns, shelvings for window dressings, cornices, entablatures, and other projections, are now in a great measure formed, and the walls will soon be ready for the roof. The front of the new building will be in a line with the park elevations of Carlton-gardens. The structure is intended to be fireproof, and will have a large elliptically-formed staircase, communicating with numerous offices through corridors which branch from it.

The new offices, we presume, have been designed by Mr. Frederick Marrable, architect to the Metropolitan Board of Works; the general contractor is Mr. George Myers, Lambeth, whose accepted tender as we understand is about £17,000.

INSTITUTION OF CIVIL ENGINEERS.

Dec. 6, 1859, and *Jan.* 17, 1860.—The discussion upon Mr. R. B. GRANTHAM'S paper, "*On Arterial Drainage and Outfalls*," occupied both evenings.

In commencing the discussion it was remarked, that the want of a comprehensive measure for the control of the arterial drains and outfalls was felt by every one practically engaged in the under-drainage of land. What appeared to be required was a central commission, something like the Inclosure Commission, not to grant compulsory powers for carrying out works, but with power to authorise the drainage of particular lands, after due investigation, when a majority of the occupiers signified their acquiescence. There was frequently great difficulty in finding an outlet for injurious water, owing to the opposition of the owners of the interposing lands; and at present a majority of improving landowners could not bind a single objector to any work, however desirable, even if it was shown that it could be carried out without injury to his property. The defective character of the obstructed and tortuous water-courses now existing was well known. There was no general law under which these could be straightened and enlarged if deficient in capacity, or new ones be cut when necessary. Lord Lincoln's Act only enabled the water-courses to be cleared out to their original dimensions. The enhanced value of agricultural property from deep drainage was generally admitted. The minimum depth recommended in clay lands was 4 feet; yet the receiving water-courses were often not more than 3 feet in depth. A remedial measure, dealing with these minor evils, was more important to agriculturists than the question of main rivers, which might be left for subsequent decision. It was true that recourse might be had to a private act of parliament, but there were many cases which, though important in themselves, were not of such extent as to justify the cost of this proceeding. The pollution of the streams throughout the country by the discharge into them of the refuse of towns, was also a subject which merited attention.

It was stated that in the neighbourhood of London, after a large sum had been expended in the improvement of a considerable district, a bridge which had been lowered was partially stopped up, owing to a trivial dispute. The drainage water was thus prevented from passing away, the produce of the land was diminished, and the health of the inhabitants was injured. There being no legal power to compel the removal of the obstruction, matters remained in this state for fifteen years. Recently, when a bill was brought into parliament for further improvements in the same district, it was opposed by one owner, who did not wish the drainage water to pass through one field of his. There was an immense quantity of land in the neighbourhood of the river Thames which might be rendered much more profitable if the drainage was only thoroughly carried out. The streams in England were not in so good a condition as those in Ireland, which had been improved under the pressure of the famine. Although the cost of these works had undoubtedly been large, the value of the land had been enhanced in a greater proportion.

It was observed that the effect of the drainage of the upper lands was to cause the water to pass more rapidly into the smaller brooks and streams in the low-lying districts. Formerly it required three-quarters of an inch of rainfall to flood the valley of the Beverley brook, whereas half an inch now sufficed, owing to some of the higher ground at Merton, Malden, and Sutton having been drained. It was believed that some legislative enactment was necessary to enable a comprehensive system of drainage to be carried out, and to provide for the maintenance of the works when made; indeed many of the evils now complained of were due to the existing drainage not being properly maintained.

On the other hand it was contended that in this country, where the rights of property were so complicated, any general measure, to be effectual, would be so injurious, by its interference with those rights, that the propriety of passing such an act was more than doubtful. A brief history was then given of the state of the drainage at different periods in the Fen districts of England, including the levels of Cambridgeshire and Lincolnshire,—and the works which had been carried out, with the results produced, were also passed under review. It appeared that in 1809, the late Mr. Rennie having been called upon by the Corporation of the Bedford Level to make an examination of the South and Middle Levels, reported that the main cause of the then existing evils was the defective state of the outfalls and of the channels of the rivers, and the bad system of internal drainage. In 1844, the proprietors of the Middle Level obtained an act to complete the interior drainage, but the works were not executed in accordance with the original design. Had catchwater drains been made between the Nene and the Ouse, the highland water would have been discharged about 30 miles above the outlet of the lowland water, the latter would have been carried well off to sea before the highland water could have reached so far, and the upland water, passing through the channel of the river, would have contributed to keep it open; whilst a supply of water could have been maintained at the higher level in dry seasons. The act of 1850 for the improvement of the outfall below Lynn, was then referred to; and it was stated, that the works it empowered to be made had caused the low water to be depressed 6 feet, making, with a former gain, a total lowering of 13 feet, besides improving the rivers Ouse and Nene, and the

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Lynn and Wisbeach harbours. As regarded the North Level, which was drained by the Nene, Morton's leam or cut for shortening the old channel of the river between Peterborough and Wisbeach, was alluded to; as well as Kinderley's cut, for improving the outfall below Wisbeach. The works completed in 1830, having also in view the latter object, had caused the low water to be depressed 10 ft. 6 in., by which both the navigation and the drainage had been improved. Many proposals were made in reference to the interior drainage of the North Level, and the upper part of the river was ultimately drained into the Ouse, according to the Middle Level plan of 1844, when the whole of the water from 55,000 acres was carried round by the Lynn outfall. The Ancholme was described as being one of those cases where a sluice was carried across a main river with great advantage. The strong current of the Humber, and the large quantity of alluvial matter with which its waters were charged, would otherwise have filled up the channel, the level would have been inundated, and the navigation been destroyed. It was urged, that the main principles on which works of navigation and drainage should be carried out, were the improvement of the rivers and their outfalls—a judicious system of main, interior and subsidiary drains, with sluices in connection with the rivers, at the most convenient places for the lowland waters, and with catchwater drains for the highland waters. As a river could only be maintained in proportion to the quantity of water passing through its bed, it was necessary to bring as much water into the channel of the river as could be discharged within a given time. In fact a perfect command of the water should be obtained, and works of drainage should be combined with those of irrigation, and with the means of storing and providing water for seasons of scarcity.

In Lombardy the rivers were larger and so different in character to those of this country, that the same system was not applicable. From the constant rising of the beds and the consequent raising of the banks, the rivers had become the repositories of debris and alluvial matter from the Alps. The beds were even in some cases as much as 20 feet above the level of the ground they were intended to drain, and the channels had to be continually altered, at great expense. On a future occasion, the best mode of preventing the debris from entering the plains, and disposing of the alluvial matter by warping, so as to keep clear the main channels of the rivers, might be discussed.

It was remarked, that individual obstinacy should not be made a subject for special legislation; and it was a question for consideration whether, in attempting to remedy the evils now complained of, greater ones might not be incurred. The fen rivers afforded examples of three different principles on which works for arterial drainage should be conducted. The Witham was a case where the outfall was, and the Ancholme where it was not, dependent upon the discharge of water from the level itself, the tide being shut out in both cases; whereas the Ouse and the Nene were instances in which the outfall was contingent upon the issue of the drainage water, but in which the tide was admitted. It was submitted that Vermuyden had erred in shutting out the tide from the Witham above Boston. Had it been allowed to enter that river would have been, it was thought, in a far better condition than it was at present. The swift current of the Humber sufficed to keep the sluice at the mouth of the Ancholme free from deposit. It was observed that both the Ouse and the Nene fairly repaid all that was expended upon them. The outfall was good in the case of the Nene, but certain obstructions required to be removed, and the banks should be attended to. The Ouse below and above Lynn was a complete river. It was evident that Vermuyden's plan, of following an inflexible rule in all cases, must not be practised; but that each river should be treated according to the particular circumstances and peculiar conditions it exhibited.

It was stated that in Mr. Walker's report of 1842, relating to the Middle Level, the entire separation of the navigation from the drainage was recommended. This, which was a new idea at the time, was thought to be impracticable, owing to the country being so flat, and to all the rivers having been previously regulated for the combination of both objects. It was imagined that a drain could not be carried sufficiently low to pass under the rivers. It having been shown however that the plan was quite feasible, a portion of the scheme was carried out. A drain 10 miles in length, the bottom of which was perfectly level, was executed, passing under one of the rivers of the district. This had the effect of depressing the level of the water 6 feet, thus greatly improving the drainage. The level of the water was completely under command. It could be kept up for the purposes of navigation, and for the supply of fresh water in summer, and be run off in winter. The Middle Level was drained in ordinary floods with an average fall of 1 inch per mile, and in extraordinary floods with not more than 2 inches per mile.

Whilst it was admitted that the Irish drainages had benefited the country, and that there was every reason to be gratified with the engineering results, it was felt that the working of the Drainage Act had been of the most arbitrary character, leading to great dissatisfaction, and that the placing of such extensive powers in the hands of a board was not justifiable. The limits of expenditure having been greatly exceeded, the works were in many cases stopped, and a commission was appointed to inquire into the affairs of eleven districts. Ultimately the ratepayers were taxed on the amount of the original estimate, the remainder of the expenditure being thrown upon the consolidated fund.

It was remarked, that by the Irish Drainage Act of 1842 the assent of two-thirds of the proprietors was requisite before the works could be commenced. When the famine occurred in 1846, an amended act was passed, in order to afford immediate employment to the labouring classes. As the surveys were made in a summary way, the commissioners were not empowered to expend more than £3 per acre without again collecting the assents. Having failed to obtain these in eleven districts, a commission was appointed to inquire into the matter. It was stated, that up to December 31, 1858, the total sum expended in one hundred and twenty-one districts, of which one hundred and ten were completed, and eleven nearly so, was only £2,342,746. There had been excavated and scoured 1450 miles of river channels, unwatering the rain basins of 6,372,000 acres, or nearly one-third of the whole country, and freeing 284,577 acres from flooding. In the one hundred and ten districts, 145,000 acres had been drained, at a cost of £5 19*s.* per acre. The increase in the annual letting of this land due to these works was £40,000. After the works were finished they were handed over to the proprietors, who had the power, under the Drainage Acts, to elect trustees, to appoint their own engineer, and to fix the amount to be raised for the maintenance of the works.

It appeared from the statement just made, that for an expenditure of nearly one million sterling, the rental value of the land had only been increased £40,000 per annum, or 4 per cent. on the outlay, which could hardly be looked upon as a success. It was considered that the discussion, so far, had not touched upon the points of real interest to the engineer, who was more particularly anxious to be furnished with an exact statement of facts in regard to the mode of dealing with any one river, whether successful or not, and as to the relative value of a tidal scour, or of back-water from land-streams. It was possible that the effect of the Eau Brink works might have been to depress the low water 7 ft. 6 in. at the upper end, but at Lynn it had risen. It had again been lowered 6 feet by the new cut; but the water at Lynn was not 13 ft. 6 in. below what it was before the Eau Brink was made; indeed it was questionable if it was 4 feet lower.

The results of the under-drainage of land were stated to have been most anomalous. Contrary to *a priori* reasoning and to preconceived notions, it was doubtful whether the floods were increased, or whether so much water flowed off the surface of the land. On the other hand, it was believed that the floods were less frequent, that more water was evaporated, and that consequently less was delivered for discharge into the rivers.

In reply to the last observation, it was remarked, that while some anomalies presented themselves with respect to clay soils which supported these views, there could be no doubt that the extension of underdraining throughout the wet lands of the kingdom had materially increased the discharge of water to the main outfalls during the winter months.

In reference to the drainage of the Eastern Fen districts, it was remarked, that at the east end of Kinderley's cut there was in 1767 a depression of the high-water level of 14 inches. This was no doubt due to the contracted nature of the channel. It showed the necessity of having ample water-ways—a point which had been neglected in some of the great works in Cambridgeshire, Norfolk, and Lincolnshire. This depression went on increasing, until at Knar Lake, 9 miles above Wisbeach, it amounted to 6 feet. It was believed that the long narrow cuts which had been proposed for the Nene and the Ouse navigation were not likely to be successful. At the outfalls there would be a confused navigation—and a great depression would take place in the level of the tidal column entering each channel. It was thought that they should be made much larger, so as to allow the tidal flow to have a greater influence.

It was urged that the outfall of a tidal drainage should be designed in such a manner, that the artificial channel, where it debouched into the estuary, should be as nearly as possible, as regarded direction, slope, and section, in harmony with the natural tidal conditions of the estuary, and of the natural deep-water channel, which formed the principal axis of the incoming tidal wave. Where this was not attended to a low-water bar was formed. When a straight cut was substituted for a natural channel, care should be taken to make the width and sectional area of the low-water channel as it entered the estuary such as to bring the slope of the water passing down the cut at its lower levels in unison with the natural slope of the tidal wave in the estuary. It was possible, that if these principles had received more consideration the works in connection with the Nene and the Ouse outfalls would have been executed at less expense, or else still greater improvements would have been effected for the same amount of money. It was important that the character and volume of the tidal wave in its passage up and down a river should be conserved. Tidal drainage might be considered as "a race against time;" and in some cases more water was discharged out of a river by a rapid retrogression of the tidal wave, than by the slower action of the current or stream. Hence the tidal mouth of a drainage channel should be proportioned to the tidal conditions of the estuary into which it debouched; and the outfall should be maintained free from bars, so as to preserve a clear entrance and exit for the lower portion of the tidal wave.

It was stated, that the plan which had been pursued by Golborne on the river Clyde, in 1768 and the following years, of narrowing the river so as to give more scour in the channel, had lessened the capacity to discharge land-floods to such a degree, that the lower part of the city of Glasgow and the surrounding country were frequently laid under water.

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Improvements had been made subsequently, but still every winter until recently the quays were flooded. The alterations effected by Mr. Walker, under the Act of 1842, had however afforded complete relief. These consisted in gradually widening the river as it approached the Frith, and increasing the depth from 2 feet, as Golborne found it, to 20 feet. At one place, which was the gorge of the river at Glasgow ten years ago, the sectional area was now three times what it was formerly. The effect had been to reduce the low-water line 8 feet, and to cause the land-floods to run off in a shorter time; and as they seldom reached 6 feet above high-water, the quays and towns were now never flooded.

The alterations which had taken place in the river Thames during the last thirty years were commented upon; and it was estimated, that since the removal of old London Bridge, ten millions of cubic yards had been dredged out of the bed of the river, to which was attributable, quite as much as to the removal of the bridge itself, the lower level of the ebb tide. In the last fourteen miles of the tide-way the low-water line had been depressed nearly 5 feet; consequently a much larger amount of tidal water entered than was previously the case. The level of high-water might perhaps be a little higher, due to the greater momentum of the tidal wave. This part of the Thames was still capable of vast improvement, and would doubtless soon receive the attention of the conservators of the river. Above the tidal range several weirs have been erected, which it was anticipated would have an injurious effect upon the drainage of the adjoining land; but in the majority of instances the land had increased in value. Where the water was not higher than 4 feet below the level of the meadow lands their productiveness was improved. The quantity of land-water discharged over Teddington Weir was believed to amount to five hundred millions of gallons every twenty-four hours.

It was thought that the objects contemplated in the paper were being lost sight of in the discussion. The author had not referred to the question of the improvement of tidal harbours, in which the endeavour was generally made to increase the depth of the water and to raise the level of the tide, so as to facilitate navigation; but to a totally distinct class of works, which was often antagonistic to the other. In drainage operations the desire was permanently to lower the outfall, and thus more effectually to get rid of upland waters, so as to bring the land into a better state for cultivation.

It was mentioned, that in the valley of York the land was exceedingly flat, and in other parts of the same county it was not more than 25 feet above the mean level of high-water at Liverpool. The difficulty there experienced in keeping lands in cultivation was very great, as large districts were frequently under water for weeks together, owing to the want of co-operation among the parties interested. It had been necessary to resort to litigation, involving an outlay of time, trouble and money, to compel the owners and occupiers of streams to put them in a proper state of repair, and to keep them cleared out. What was much needed was some power to make the owners of land near the outfalls of large districts preserve them in such a state as not to injure their neighbours.

It was contended that the lowering of the outfall for drainage in a tidal river or estuary could not be considered without taking into account the effect of the admission of the tide. No river could be maintained without a large quantity of water passing through it, and this depended more upon the tidal water which was allowed to enter the channel, than upon the fresh upland water flowing down. The more water that was admitted, the greater would be the scour, and the low level of the water would be depressed, which would be beneficial both for navigation and for drainage.

It was thought that this subject could not be fully discussed without including in the inquiry all kinds of drainage, agricultural, ordinary river, tidal, and even town drainage, the latter of which was much mixed up with the question of outfall. It was believed that in many parts of the country the land was over-drained; in other words, that the water-level in the ground had been depressed so much as to render the surface unfit for the growth of many kinds of crops. In one part of the fen districts, of half-a-million acres in extent, the farmers were in the habit during the summer of obstructing the drainage, and in some cases even of bringing water from the adjacent rivers through the drainage-pipes to feed the ground, because it had been found by experience that the weight of the crop was diminished if the water was drawn off below a certain depth. Under-drainage was too often conducted without regard to the different qualities of the soil, and the circumstances of each case: thus valuable salts were frequently washed out of the soil. It had been said that many estates could not be drained, because the proprietors of the lands near to the outfalls would not concur in the proposed improvement. This difficulty was believed to be more imaginary than real. It arose mainly from some one wishing to drain his land at another person's expense; for the object could readily be obtained provided it was paid for. There was no good reason why what was termed an improving landlord, who wished to give an additional value to his estate beyond its natural condition, should not pay for the benefit. Besides, in most parts of England, if not in all, there was already in existence a valuable commission—the Sewers Commission, originated in the reign of Henry VIII.—which had charge of all the water-courses. By setting that commission in operation it was possible for any person to get his land drained, as far as he had a legal right to do so. If he wanted more than legal rights, parliament was the proper tribunal to apply to. At all events, a government board was the last thing that should be resorted to;—and it was believed that private enterprise, assisted by proper local authority, unconnected with government, would be incomparably superior. It was argued, that although the tidal water might play the principal part in estuaries, and in the portions of those rivers discharging into estuaries which were within tidal action, yet that the upland water had in many cases a most beneficial effect. For however small in quantity, it was contended that it determined the advance to the sea of any particular deposit or matter in suspension, and tended to keep the channel open. Under these circumstances the object should be to get at the head of the stream as large a quantity of upland water as possible.

In reply to the observations which had been made, it was stated that the paper merely alluded to the difficulty of carrying out inland drainages on a large scale, owing to the want of legislative powers. No remedy had been suggested; and certainly it was never contemplated that such powers should be placed in the hands of a central commission, constituted like the Board of Health. But the working of the Tithe Commission, and more particularly of the Inclosure Commission, had proved very satisfactory to the agricultural interest, and perhaps something on a similar model might be found useful for facilitating arterial drainages and outfalls. No control whatever was exercised by the board last mentioned—their operations being entirely of a permissive character. It was at first intended to group all rivers into classes, according to their circumstances and conditions, and then to endeavour to assign to each the particular mode of treatment applicable to it. But that was found to be too complicated; and hence the only division adopted was into rivers flowing over a flat country, and those running through upland districts. A description had also been given of the works which were necessary in those cases where the drainages were connected with tidal rivers, and where they discharged into internal streams. The Indian rivers had been referred to, as they afforded examples of works on a large scale, and offered excellent lessons of the mode of training rivers, bringing down quantities of sand, stones, and sedimentary matter.

It was admitted in explanation, that under-drainage, when judiciously carried out, had the effect of materially improving cultivation. There were many instances however in which it had been pernicious, not perhaps invariably, as every fifth or sixth year there might be a great deal of rain, but in intervening years it was decidedly injurious. As a rule, drainage should be limited to a moderate depth, and the drains should be more numerous. Where under-drainage was too deep the surface was unduly dried, and green crops requiring a large amount of moisture, such as turnips, beet-root, and mangold-wurzel, were liable to perish. In such cases it was only possible to raise cereal crops, and when the drought was continuous even the produce of these was diminished.

It was contended that the object of the Inclosure Commission was to dissolve partnerships which were disadvantageous and unsatisfactory to all parties; and therefore the sooner they were abolished the better. Whereas the reverse would be the case with a commission appointed to deal with rivers, estates, buildings, or mills, as the purpose then would be to compose a partnership, and to make people concur in an act which they or some of them had an objection to.

In closing the discussion it was remarked, that many of the bars on the coast of England had no connection with the outfall of rivers, and that there were cases in which the land water obstructed and diminished the quantity of the scour. The level of the land, the nature of the soil, and many other circumstances, must be taken into consideration in determining the depth to which under-drainage should be carried. The late Mr. Tycho Wing had found that in the fens the best depth was 2 ft. 6 in. below the surface. There were two kinds of drainages to be considered, one where the drainage water must be discharged into rivers under tidal influence, and the other, into streams wholly independent of and unconnected with the tide. It was a difficult question to determine how far the government ought to interfere, having regard to the preservation of existing rights, either by means of a commission or other machinery, in forwarding drainage operations; which frequently involved giving permission to some persons to benefit their lands, by compelling others to allow works to be executed on their property. On the whole it was believed that private rights, which gave a value to property, should be strictly upheld, and that such powers as were sought should not be placed in the hands of any tribunal under the control of government.

After the meeting of January 17th, Mr. S. Alfred Varley exhibited *a Cracked Bell*, the metallic continuity of which had been restored by simply soldering the crack with tin, so that the bell rang as perfectly as before it was injured. It was explained that tin had the property when heated above its melting point, to nearly a red-heat, of rapidly dissolving copper. If therefore the cracked bell, after being soldered, was kept at a dull red-heat, or nearly so, for a little time, the crack would become filled up with an alloy of tin and copper of nearly the same kind of composition as the bell itself, and in absolute metallic union with it, and quite as brittle and as sonorous as the other portions of the bell.

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ON THE STRENGTH OF IRON SHIPS.*

By JOHN GRANTHAM.

ON the ocean the question of safety must always, in the peculiar sense, be relative; and in respect of the strength of iron ships there is but little information to be derived from what is known of wooden ships, owing to the utter want of analogy between the modes of connection or fastenings adopted in the two cases. It must be by contrast rather than by comparison that their relative merits could be seen.

Many attempts have been made to diversify—the author could not say improve—the system of iron ship building which has from its origin prevailed. The diagonal system, although the subject of a recent patent, has for the last twenty years been a matter of frequent discussion, and is of doubtful value as an improvement. The ordinary signs of weakness, and the remedies to be applied, were noticed at some length. Any one who had seen the difficulty of building a diagonally-fastened iron ship, the derangement of the beam ends and of the bulkheads, and the great additional cost which it must entail, would admit that its advantages should be very well ascertained before it received a preference over the old system. Diagonal fastenings are however advantageously applied to large and long iron ships in the braces used in the decks—consisting of flat bars running across under the planks, and screwed to each beam—but in this case we have to deal with planks, so that diagonal fastenings are here consistent with sound principles.

Another novelty noticed was the cellular system, of which a remarkable specimen is seen in the Great Eastern. In her, portions of both the hull and the deck are cellular. In the case of the deck the application seems to be good, but the author doubted the expediency of the hull being thus constructed. In a smaller ship, the difficulty of painting and cleaning the inner portion and the space lost would be grave disadvantages, and the safety which the double skin affords is unnecessary where there are plenty of bulkheads. The system of longitudinal bulkheads in a very large vessel has no corresponding disadvantages, and affords an enormous addition to the strength.

In reference to riveted seams, of which the vertical or butts are the most important, the author said the principles laid down in Lloyd's regulations are as good as any that have been given.

Many erroneous views have arisen respecting the strength derived from bulkheads in iron ships. In two cases which he remembered, where the author had paid particular attention to them, many lives were saved by their means. When bulkheads were first applied, many builders punched rows of holes in direct lines around the ship, making a partial severance of the structure. Others ran into the opposite extreme. But the author's main object was to consider the strength afforded to the whole structure of the ship by bulkheads. This inquiry was necessary, as some had denied their utility in this respect. The author however would increase their number where possible. This would not be so inconvenient as might at first be supposed. Indeed, it frequently led to useful facilities, by requiring for example a greater number of hatches, which in long ships are easily arranged, and thus increasing the dispatch of loading and discharging the ship. But granting that in some cases inconvenience may arise, the safety derived from well-arranged and well-made bulkheads should be paramount.

All scientific shipbuilders address themselves to the question of "fastenings" as a leading object. The numberless short unyielding rivets employed in uniting their different parts give to iron ships a preeminence which can never belong to wooden ships. The author denounced the practice of adding large masses of timber to iron ships as a means of giving strength, and alluded to the Liverpool floating stages, of which one, constructed with longitudinal ties of timber, takes the form of every wave in rough weather, while the other, whose longitudinal ties are of iron, exhibits but a slight tendency to bend under the same circumstances.

The effect of experience in iron ship building should be to remove excessive weight in one part and add more weight to other parts, until uniform strength is attained. At present the author's observation leads him to believe that signs of weakness are now most frequently to be observed at the gunwale and sides amidships, and at the hollow ends below the water line. In the rules laid down by Lloyd's committee, the strengthening of these parts had not been duly provided for. The Royal Charter presented a remarkable example of the defects alluded to, and the author quoted from his published work on 'Iron Ship Building,' a passage bearing upon this subject, which was written after he had examined that vessel in the graving dock some time ago. He then discussed the three following questions, viz.: 1, the form and proportions to which the use of iron in ship-building tends; 2, the important bearing which form and proportion have upon strength; 3, how these tendencies should be dealt with in iron ships. The tendency which the employment of iron in shipbuilding has given rise to, is to build vessels, especially steamers, much longer and finer than they were before. The author had frequently examined one vessel, that had sailed round the world, whose length is nine times her breadth. A much greater proportion of length to breadth may be ultimately attained, especially in large vessels. But the excess of weight over displacement at the ends will increase in the same ratio, unless precautions are taken to reduce the weight there. It is clear, however, that a vessel should be so constructed, and, where possible, so loaded, that when in smooth water the weight should as nearly as possible correspond with the displacement of every portion. The same conditions will also obtain when the circumstances of a ship taking the ground are considered. The construction of the Royal Charter was then examined at length, and her weakness attributed, not to badness of material, nor to inferiority of workmanship, but solely to the defective principles upon which she was designed. The author contended for a great diminution in the weight of iron ships at their extremities; and stated that Lloyd's rules operated injuriously by narrowing too much the sphere of improvement. He also considered it inconsistent to class iron ships for years, as was at present done. He further held it important to bear in mind, that the chief strain which a ship has to sustain, is similar to that which is required in an ordinary girder, and that any serious departure from this principle will lead to errors of construction. The Great Eastern was, perhaps, the only large vessel in which this principle has been effectually applied; and although the exact form there adopted could only be employed in very large ships, yet the principle is correct, and probably the proportions also. He concluded by a strong appeal to Lloyd's committee fundamentally to alter their regulations, and to issue them as recommendations, and not to make them binding: also to private builders, to study good work—quality being in all cases better than quantity.

* From a paper read at the Institute of Naval Architects.

THE EXHIBITION OF THE INSTITUTE OF THE FINE ARTS.

ARCHITECTURAL subjects in this exhibition are this year fewer and less important than usual. The names of several old contributors of works of this class are wanting in the catalogue, a fact which is observable in other departments, while the new aspirers do not adequately fill the ranks. Mr. L. J. Wood in his cabinet-sized pictures maintains his position as an exponent of picturesque architectural groupings, principally from abroad, as his scenes from Rouen, Lisieux and Evreux, will testify. More interesting, however, are the three English pictures by Mr. T. Soper, so carefully detailed and cleverly coloured. Of these (236) Cleeve Mill is the most artistic as well as architectural. Two views at Mottistone, Isle of Wight (211 and 450), by Mr. J. J. Hardwick, are very good; the old house (simple and apparently intact, except by time), which is the subject of the latter picture, is more attractive than the view of the church. There are several gleanings from Venice, as usual, but none of particular merit. One of the best (2) is due to a lady, Mrs. W. Oliver, and represents the "Grand canal and Santa Maria de la Saluti." In (18) Mr. C. Marshall shows a glowing scene—Lake Lagano, rich in elegant campanile; and the "Port of Genoa" (58), by Mr. Parrott, is a work in which the buildings absorb no small share of the interest. Two of these are shown more in detail in (104 and 162), St. Pierre d'Arena," and "A Genoese portico," respectively. (67) "Portel, a French fishing village," by Mr. Smythe, is noticeable for the crude picturesqueness of the dwellings, and the same remark is applicable to (87) Mr. Henshall's "Near the cathedral, Abbeville." (237) "Grand porch, Rouen Cathedral," is minutely shown as to detail, considering the scale of the picture; and his views of the churches at Dieppe and Rouen (293 and 302) are also praiseworthy. (92) "Interior of a country church," though it does not embrace much, is a clever work, and

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has an air of truthfulness about it. "The island of Philæ" (118), by Mr. Burnett, shows the ancient ruins for which it is so famous: and the "Ruins of a Roman bridge at Tangiers" by the same artist (416), will be examined with interest.

The view of "Valle Crucis Abbey" (130) by Mr. Godet, is a capital subject, and nicely shown, as is also his "Carisbrook Castle" (251)—the *entrance* gateway only, by the bye. At "Bacharach, on the Rhine" (170, by R. H. Nibbs), is a curious half-timbered house, with one of those fanciful steep-pitched roofs which impart so much variety of feature to the characteristics of that locality. With a passing mention of (246), Mr. Holder's "Remains of Kenilworth Abbey," but which is in reality a not very flattering exposition of the detached entrance ateway only, we shall have done fair justice to the architectural claims of this exhibition.

In landscapes, Messrs. Sidney Percy, G. A. Williams, J. Peel, E. A. Pettitt, and others, are well represented as heretofore; likewise in the pourtraying of homely and domestic scenes, Mr. Rossiter in (56) "The dancing lesson," (382) "A fisher maiden,' and (459) "The little student," comes forth with less crudity than of late years, without losing an atom of impressiveness. The pre-Raphaelite element is indeed generally by no means so evident as formerly, notwithstanding the contributions of Mr. Smallfield, and a few others. There is one large picture, however, with a disguised title (80), which smatters strongly of this quality; it depicts evidently a cherished spot, and is no doubt painted *con amore:* Mr. B. Leader, the artist, has several others on the walls which cannot be passed by unnoticed. Mr. Naish's study from Kingsley's "Ode to the North-east wind, (346) may be quoted as unusually powerful in treatment, as is also Mr. Hay's "Crotchet" (147), a bit of Etty-like colouring. "The deserted home" (11), A. Finlayson, and "The unwelcome guest" (142), J. D. Adam, are also choice specimens of art.

REVIEW.

A Manual of the Steam Engine and other Prime Movers. By W. J. Macquorn Rankine, C.E., LL.D., F.R.S., &c. &c.—London and Glasgow: R. Griffin and Co.

A more careful perusal of Prof. Rankine's book has in nowise diminished our high estimation of its value, whether regarded in the light of a scientific treatise on the theory of mechanics, or as a handbook for practical reference. It is indeed far too copious, and partakes too much of the nature of a cyclopœdia, to be dismissed summarily in one notice. We shall not attempt to follow systematically our author through all the subjects of which he treats: our present intention is from time to time to direct our readers' attention to such parts of the book as seem to us most interesting either from their novelty or usefulness. We may however parenthetically remark that the author's manner of stating his propositions does not always appear to us to be so clear as his reasoning invariably is; and we rather object to his augmenting the nomenclature of mechanical analysis, by new names for the measures of forces, according to the circumstances under which the forces act. We do not feel much affection for even such old and well-known expressions, as "vis viva," "work done," and the like, preferring at once to start from the fundamental equations of equilibrium; much less do we feel well at home in the use of words like "effort," "energy stored," "energy restored," and others, *ejusdem generis*, which we meet with scattered throughout these pages. Nor do we think that the professor will have rendered his work more intelligible by the sketchy outline of mechanical principles, and of the meaning and nature of integration, which we find in the introduction; as it is clear that without a much more intimate knowledge of mathematics than could be furnished by such hints, no one need attempt to follow the author through his reasonings, however generally available to all readers, learned or unlearned, may be the practical results obtained. We mention these points not as blemishes, but as useless excrescenses in a treatise possessing so much sterling excellence.

We propose at present to consider the simple but complete way in which the professor has treated the subject of work done by water on water-wheels. To determine theoretically the amount of resistance to a current experienced by a fixed obstacle, is in general beyond the power of analysis, but there are cases in which this problem admits of at least a tolerably approximate solution. Such we believe to be the resistance of a mill-wheel float to a stream impinging on it, when the sectional area of the stream is much less than that of the float,—and we give Mr. Rankine's method of solving this problem:—

"*Impulse of Water on Vanes.*—The action of water 'by impulse' against a solid surface, is that pressure which is exerted by the water against the surface in consequence of the velocity and direction of the motion of the water being changed by contact with the surface.

The direction and amount of the pressure exerted by a jet or stream of water against a solid surface are determined by the following principles, which are the expression of the *second law of motion* (already cited in Articles 14, 29, 30), as applied to this case:—

I. The direction of that pressure is opposite to the direction of the change produced in the motion of the stream during its contact with the surface.

II. The magnitude of that pressure bears to the weight of water flowing along the stream in a second, the same ratio which the velocity per second of the change in the motion of the stream bears to the velocity generated by gravity in a second (viz. $g = 32{\cdot}2$ feet per second).

It only remains to be shown, how the direction and velocity of the change of motion of the stream are to be determined.

In what follows, the effect of friction between the stream and the vane is supposed to be insensible.

In each of the Figs. 1, 2, 3, 4, A represents the stream or jet, and B the vane. Fig. 1 represents the case in which the vane guides the stream in one definite direction EF; and the solution of this case leads to or comprehends the solution of the others. Figs. 2 and 4 represent cases in which the vane has a plane surface, and the stream glances off it in various directions. In Fig. 2 the vane is perpendicular, and in Fig. 4 oblique, to the direction of the stream. Fig. 3 represents a concave cup-shaped vane, turning the stream backwards. Corresponding lines on the different figures are marked with the same letters.

A jet of fluid A, striking a smooth surface, is deflected so as to glide along the surface, and at length glances off at the edge E, in a direction

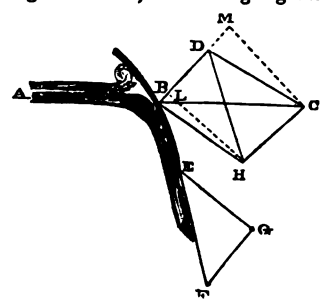


Fig. 1.

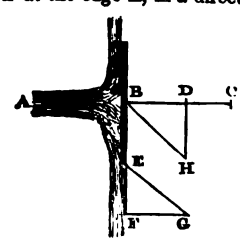


Fig. 2.

tangent to the surface. As the particles of fluid in contact with the surface move along it, and the only sensible force exerted between them and the surface is perpendicular to their direction of motion, that force cannot accelerate or retard the motion of the particles, relatively to the surface, but can only deviate it.

When the surface has a motion of translation in any direction with the velocity u, let BD represent that direction and velocity, and BC the direction and original velocity v of the jet. Then DC represents the



Fig. 3.

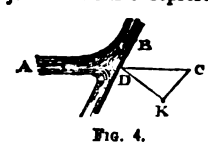


Fig. 4.

direction and velocity of the original motion of the jet relatively to the surface. Draw EF = DC tangent to the surface at E, where the jet glances off; this represents the relative velocity and direction with which the jet leaves the surface. Draw FG ∥ and = BD, and join EG; this last line represents the direction and velocity relatively to the earth with which the jet leaves the surface, being the resultant of EF and FG.

I. *General Problem.*—Draw $\overline{DH}$ parallel to the tangent EF, and equal to DC; then will the base $\overline{CH}$ of the isosceles triangle CDH represent the direction and velocity of the *change of motion* undergone by the jet during its contact with the vane; so that, according to the first of the principles already laid down, HC is the *direction* of the pressure exerted by the jet against the vane; and, according to the second of those principles, the *magnitude* of that pressure is

$$DQ \cdot \frac{\overline{HC}}{g} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

when DQ is the weight of the flow of water in a second.

But the whole magnitude of that pressure is of less importance than the magnitude of that component of it which is an *effort* as respects the vane; that is, which acts along the direction BD of the vane's motion.

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To find that effort, $\overline{HC}$ in equation 1 is to be replaced by its projection on BD, viz. $\overline{LM}$; HL and CM being perpendiculars let fall on BD from the two ends of HC. Therefore, let P denote the effort required; then

$$P = DQ \cdot \frac{\overline{LM}}{g} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

and the *energy per second* exerted by the jet on the vane is

$$Pu = DQ \cdot \frac{\overline{LM} \cdot \overline{BD}}{g} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

[In Fig, 2, the line corresponding to $\overline{LM}$ is simply $\overline{DC}$, the difference between the velocities of the jet and the vane.]

To express these principles algebraically, let

$v_1 = \overline{BC}$ denote the original velocity of the jet;

$u = \overline{BD}$, the velocity of the vane;

$\alpha = \angle DBC$, the angle between the directions of those velocities;

$\gamma = \angle MDH$ = supplement $\angle EFG$, the angle which a tangent to the vane at the edge where the jet leaves it, makes with the direction of motion of the vane; then,

$$\overline{BM} = v_1 \cos \alpha; \quad \overline{DM} = v_1 \cos \alpha - u;$$
$$\overline{DH} = DC = \sqrt{(v_1^2 + u^2 - 2uv_1 \cos \alpha)}.$$

$\overline{DL} = -\overline{DH} \cos \gamma$ (in which it is to be observed that cosines of obtuse angles are negative); and, consequently,

$$\overline{LM} = v_1 \cos \alpha - u - \cos \gamma \cdot \sqrt{(v_1^2 + u^2 - 2uv_1 \cos \alpha)} \quad \ldots \quad (4)$$

$$P = DQ \cdot \frac{1}{g} \left[v_1 \cos \alpha - u - \cos \gamma \cdot \sqrt{(v_1^2 + u_2 - 2uv_1 \cos \alpha)} \right] \quad \ldots \quad (5)$$

$$Pu = DQ \cdot \frac{1}{g} \left[uv_1 \cos \alpha - u^2 - u \cdot \cos \gamma \cdot \sqrt{(v_1^2 + u^2 - 2uv_1 \cos \alpha)} \right] \ldots (6)$$

If the final velocity of the water, $\overline{EG} = \overline{BH}$, be denoted by v_2, its value is

$$v_2 = \sqrt{(\overline{BD}^2 + \overline{DH}^2 + 2\overline{BD} \cdot \overline{DH} \cdot \cos \gamma)} = \sqrt{[v_1^2 - 2u(v_1 \cos \alpha - u) + 2u \cdot \cos \gamma \sqrt{(v_1^2 + u^2 - 2uv_1 \cos \alpha)}]} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

From which it is evident that equation (6) is equivalent to the following:

$$Pu = DQ \cdot \frac{v_1^2 - v_2^2}{2g} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

that is, the energy exerted by the water on the vane is equal to the actual energy lost by the water, a consequence of the assumption that the friction is insensible."

This reasoning is perfectly sound, provided that the area of the float be much greater than the area of a transverse section of the incident stream, and provided also that there be no *splashing*. Further on Mr. Rankine has made allowance for the elasticity of the water, but he has not, as we think he ought to have done, pointed out the necessity of the float being much larger than the sectional area of the stream, without which condition his reasoning would entirely fail; as only a portion in that case, and not the whole of the stream, would be diverted from its original direction and glide off tangentially to the float. To take a simple instance, that of a stream impinging directly on a fixed board;—it is easy to show that if the area of the stream before it begins to spread out, and where its velocity is constant (gravity not being reckoned) be equal to the area of the float, then the formula given by Prof. Rankine is at least twice as great as it ought to be; that is, if we understand correctly the meaning of his term "flow of water." For let the plane of the resisting board be taken for the plane of (x, y) a normal to the surface for the axis of x, and let s be the path of a fluid element, measured from any point in its course at such a distance from the board that the velocity is constant, and the same for all the elements of the stream there: then if the density of the water be taken equal to unity, we have the well-known equation

$$v \frac{dv}{ds} = -\frac{dp}{ds}$$

where p is the pressure on an unit of surface, and v the velocity at any point x, y, z in the path s (gravity not being considered);

and $\therefore \frac{v^2}{2} = -p + c.$

Let V be the velocity of the stream when constant, and when the sectional area of the stream is = A, that of the board; v' the velocity of the fluid element when in contact with the board; p' the pressure that would be exerted on an unit of the board by the stream, supposing that throughout an unit of surface it were the same as at the given point. Then $p' = \frac{V^2 - v'^2}{2}$ Now if p be the total pressure on the board,

$$P = \iint \frac{V^2 - v'^2}{2} \, dx.dy$$

which is less than $\iint \frac{V^2}{2} \, dx.dy$, or which is less than $\frac{V^2 A}{2}$. But Prof. Rankine's method in this case would give $V^2 A$ for the total pressure.

It would appear then from this investigation that it would be advantageous to make the floats as large as practicably possible in comparison with the stream, and this seems to be done in the Poncelet wheel. Where the wheel is overshot, great part of the work done by the water is due solely to its weight collected in the buckets; the author has pointed this out, and given numerous illustrations of the different kinds of water-wheel in use at the present time. By a somewhat similar train of reasoning to that adopted by the author in the passage above quoted, we can obtain approximately the ratio of the area of the *vena contracta* to the small orifice from which the stream emerges. Our readers are aware that when a fluid escapes from a very small orifice at the bottom of a reservoir the sectional area of the stream contracts rapidly to a point a little distance below the orifice, and thence for a short distance continues approximately constant. The area of the stream where so contracted is called the area of the *vena contracta*.

To determine the amount of contraction, let A be the area of the small orifice, h the area of fluid above; let its density be taken as unity, and g the accelerating force of gravity; let A′ be the area of the *vena contracta*; v the velocity of the particles of fluid there. Then $v^2 = 2gh$. But since in the time one second a velocity v has been communicated to a mass A′v of fluid by a pressure which is equal to Agh very nearly,

$$Agh = A'v^2$$
$$\text{and } 2gh = v^2; \quad \therefore \frac{A}{2} = A';$$

and we believe, if it were not for the fluid friction, which is considerable, this expression would be extremely approximate.

The discharge of water from pipes, when the pipe is not of uniform bore, or if it be interrupted by branches, is a problem utterly hopeless when attacked by pure analysis. Prof. Rankine has given a collection of practical formulæ in bearing on this subject, and also on the discharge of water from weirs, &c.; but it would be probably impossible to include all cases under such formulæ, and we apprehend that they would only be reliable when the constants in the problem of which the solution is sought do not differ much from those in the experiments which have established the formulæ.

We have noticed by the way a misprint in one of these formulæ,—page 102, section v., for c a coefficient of contraction whose value may be taken at $\cdot 62 \div \sqrt{1 - \cdot 62 \frac{a^2}{A^2}}$, it ought to be $1 \div \sqrt{2 \cdot 62 - 1 \cdot 62 \frac{a^2}{A^2}}$,—at least, if what follows is correct. The first is clearly wrong, as it ought to reduce itself to unity when $A = a$.

The following is a neat and very easy mode of obtaining approximately the height of a station by barometric measurement, as given by Prof. Rankine. When the elevation is not very considerable, say less than 1000 feet, deduct from the pressure one hundredth part of itself for every 262 feet of elevation. Thus, let h, h' be the heights of the barometric column at the bottom and summit of a hill, x the height of the hill in feet. Then $h - \frac{h \cdot x}{100 \times 262} = h'$, or $x = \left(\frac{h - h'}{p}\right) \cdot 26200.$

Exhibition of Works of the late Sir W. Ross.—The Society of Arts propose to do honour to the memory of the late Sir William Ross, R.A., by getting together, in their rooms in the Adelphi, a collection of his works, for exhibition to the public during the months of April and May. Sir William Ross in his early days received several medals from the society. Possessors of his works will do well to lend them to the society for this exhibition, and should at once communicate with the secretary. It is understood that the Queen and the Prince Consort will contribute to the exhibition from the royal collection.

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NOTES OF THE MONTH.

The Late Mr. Joseph Miller, Engineer.—The last American mail brought intelligence of the death of Mr. Joseph Miller, the well-known marine engineer. He expired at Charlestown, South Carolina, on the 23rd of February, in his sixty-third year. Mr. Miller had for a number of years from infirm health withdrawn from his profession. He was a native of Carlisle, and served his apprenticeship at the Soho Foundry of Messrs. Boulton and Watt. He became chief engineer at the Butterley Iron Works, and there commenced that career as a marine engine maker, which, continued and extended under the names of "Barnes and Miller," and "Miller and Ravenhill," has given to his name a well-earned reputation. To him is to be ascribed an important share in those efforts at simplicity in design, elegance and lightness in proportion, and soundness of workmanship which have brought the marine engine to its present excellence. His firm worked extensively in the formation not only of our own steam fleet, but of those of many foreign governments, and on the Thames, and between Dover and Calais, and on the Rhone and the Soane, the Danube, and the Rhine, some of the earliest and most successful efforts at rapid steam navigation were made by vessels supplied with his engines. Mr. Miller was a Fellow of the Royal Society.

The Brunel Memorial.—About £2000 have been already obtained towards the Brunel Memorial. The committee, who consider the matter sufficiently advanced for some decision to be taken as to the form of the memorial, held a meeting on the 30th ult. for that purpose.

The Serpentine.—Orders have been given to suspend the works undertaken for the purification of the Serpentine by filtration, on the plan proposed by Mr. Hawksley;—the evidence given before the committee being unfavourable to the system adopted by that gentleman. The cost of the works already executed will amount, it is said, to £10,000.

The Great Eastern.—The directors of the Great Ship Company have decided upon immediately completing the whole of the work necessary to fit the Great Eastern for sea, so as to meet the requirements of the Board of Trade, and have selected Mr. Charles Lungley, a thoroughly practical shipbuilder, of Deptford, to do all that is required to the ship, and Messrs. Summers and Day, of Southampton, to complete the machinery. A careful examination has been made of all parts of the ship by Captain Carnegie, Mr. Brereton, and Mr. Lungley; and of the machinery by Messrs. Penn, Field, and Gooch.

The ruined Church in Dover Castle.—It is stated that the ruined church in Dover Castle is about to be restored by the Government under the direction of Mr. G. G. Scott. Every part of the old work will be carefully preserved and shown as far as is practicable, a new roof will be put on, and the church restored to use as a chapel for the garrison.

The Suez Canal.—The works of the Suez Canal are proceeding vigorously. The excavations have commenced along the whole length of the line. A Russian officer is stationed at Suez to superintend the progress of the undertaking in conjunction with the French engineers.

The Liverpool Society of Fine Arts.—At the annual meeting of the society, held on the 10th ult., the council reported that they had assumed office when there was a debt to the amount of £855, for expenses incurred in establishing the society, and adapting the Queen's Hall for an exhibition gallery; and that during their year of office this debt was reduced to £420, more than one half having been liquidated. In addition to this, a commencement had been made of the Permanent Gallery of Modern Art, by the purchase of Mr. Pyne's picture of "Angeria, with the Port of Arona, Lake Maggiore." The sales of the late season realised an unusually large amount,—£4858, of which £1600 were spent in the works of continental artists, and the remainder in works of the British school,—the latter, £3200, being supposed to be without precedent out of London. Arrangements have been made for an exhibition of the works of ancient and modern masters, proof engravings and photographs, to be opened on the 2nd of April, thus supplying a desideratum in Liverpool, where there is no spring exhibition of works of art. The council have received very satisfactory offers of contributions, notwithstanding the numerous applications to which the owners of valuable works are subjected.

Conversion of Iron into Steel.—Mr. Brooman's powder for converting iron into steel is composed of equal parts of caustic, lime, bone-dust, and charcoal, and is exposed to the air for two or three days in dry weather, to enable the lime to absorb carbonic acid. The iron to be operated upon is placed with the powder in a cementing furnace, sealed up, and exposed to a regular but not very high temperature. Iron thus treated assumes rigidity and hardness, without losing its malleability and ductility.

Magnetical Observations in Africa.—Dr. Livingstone has communicated to the Royal Society a series of valuable magnetical observations made recently in Africa.

The Society for the Encouragement of the Fine Arts.—This society held its second conversazione for the season on the 22nd ult., at the Portland Gallery, Regent-street. Mr. J. A. Heraud read a paper on "The Ideal in Art;" the pictures on the walls supplying a commentary on that text. This was followed by an instrumental and vocal concert.

British Archæological Association.—At the meeting of the 14th ult. Dr. Kendrick sent for exhibition, from the Warrington Museum, an Egyptian papyrus MS. presented by Col. Legh, the traveller. It was in the Hieratic character, and had been found in a mummy-case at the Memnonium at Thebes.—Mr. Pettigrew read the name *onkhf-n-khons*, and exhibited other specimens of cases and papyri from his own collection.—Mr. T. Wright exhibited an iron box found at Wroxeter. It had been sawn through, and was found to be in four divisions, all filled with wood.—Mr. Forman exhibited a fine steel plaque, which had formed a panel of a German coffin of the sixteenth century. It presented an unusual representation of a *Bear* hunt. *Boar* hunts are common.—Mr. H. Seyer Cuming exhibited a fine specimen of needlework, representing the Virgin and four attendant cherubs. It was of the early part of the seventeenth century.—Mr. Gunston exhibited a curious and very diminutive object in bronze: a human head, with slender ram's horns. It was found in boring for a well at Carshalton, in Surrey.—Mr. Mark Philips exhibited the impression of a massive gold ring, found in the Thames, near Brentford. It is a merchant's mark, and belongs to Sir W. Clay, Bart.—Mr. Vere Irving and Mr. A. Sim exhibited further antiquities from Lanarkshire, partly Roman and partly Mediæval. They were ordered to be recorded and figured.—Mr. Serel communicated a curious paper, giving an account of the entertainments and shows provided by the corporation of Wells for the amusement of Queen Anne in 1613. It will be printed with other original documents.—The chairman announced that the Congress at Shrewsbury would be held from the 6th of August to the 11th, inclusive.

Town-hall of Ypres.—The restoration of the old and beautiful town-hall of Ypres, formerly the capital of West Flanders, is now complete. The pictorial ornaments of the stately building, the statues of thirty-one sovereigns who bore the title of Counts of Flanders have been replaced in the façade.

Improvements in Paris.—M. Viard has submitted to the Emperor a plan for a new railway waggon for the conveyance of passengers through Paris. The carriage has eight wheels, it is 30 feet long and 9 feet broad; four horses are sufficient to draw it. Each carriage will accommodate 100 passengers inside, and as many outside; with a roof on the top for winter, which may be removed in summer: the fare for each inside passenger to be 10 centimes, outside half price. Rails are to be laid on the ground occupied by the old wall of Paris.

Competition.—Architects of Great Britain, Ireland, and France are invited to furnish designs for New Houses of Parliament to be erected in Sydney, New South Wales. £600 will be awarded for the approved design, and £300 for the second best. The style of architecture is left to the competitor. Drawings and estimates to be sent under sealed covers, addressed to the Secretary of Public Works, Sydney, to the care of Messrs. William L. Merry and Co., 36, Cannon-street, E. C. (the commercial agents of the New South Wales Government), for transmission to the colony by steamer. General conditions, together with a contour plan, may be obtained on application to Mr. Weale, 59, High Holborn; Messrs. A. and C. Black, Edinburgh; Mr. H. Campbell, Argyle-street, Glasgow; Messrs. Hodges and Smith, Dublin; Messrs. Philip and Son, Liverpool; Messrs. Thompson, Manchester; or M. Amyot, No. 8, Rue de Paix, Paris. At each establishment photographic views of the locality may be seen. Mr. Weale will give such explanations as may be desired of him by personal application or by post. Designs to be sent in by the 1st January next.

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THE ARCHITECTURAL EXHIBITION.

THE tenth season of this Exhibition, and the second in its established locality, was inaugurated by a *conversazione* on the evening of the 10th ult., almost a month later than the corresponding meeting last year. It was very well attended, as usual, the members of the profession mustering, as it appeared to us, in unusually large numbers. The proceedings of the evening were varied by addresses from the chairman of the evening, Prof. Cockerell, also from the acting hon. sec., Mr. Edmeston, who alluded in cheering terms to the healthful and progressive condition of the institution, and from Mr. E. B. Lamb. An apology was made for the absence of the excellent treasurer, Mr. Ashpitel, through ill-health, and allusion made by more than one speaker to the loss which the Architectural Exhibition, in common with other establishments devoted to this branch of art, had sustained by the decease in the course of the past year of the Earl de Grey, its president. It was also stated that the "Society for the Promotion of the Fine Arts," which has been recently instituted (and to which reference is made in another page of this month's Journal) purpose bestowing a prize on the most meritorious design exhibited this year either in the Conduit-street Galleries or in the Royal Academy. With these encouragements and those opportunities, we shall hope to see greater results than heretofore. It is manifestly evident, however, that the profession are as yet far too sluggish; they might help and be helped much more than they seem disposed to imagine. We have insisted upon this from time to time, as have other well-wishers to the art, but with inadequate success. The Architectural Exhibition should be a yearly exponent of the profession at large, each member contributing his share of work in one shape or other, so that the aggregate might in point of numbers and value be such as to warrant and induce repeated visits of profitable study for future use. Till this is conscientiously done we ought not to rest satisfied, and till the profession not only assent to the undoubted fact, but can be induced to co-operate, we shall not shrink from administering our periodical stimulus. We must again assert that it is practical delineations which are most serviceable, though perhaps least attractive, and of these every architect is able, though as yet, it seems, not willing, to send his quota. These, in fact, with a well-arranged and ample list of *competition* drawings, should constitute the staple of our Exhibition; fancy designs, and even pretty sketches from old examples, forming the exception, and not the rule. What then is to be said of pretty drawings—merely as such? Why, let them cast in their lot among the *picture* exhibitions, there they will be in their proper sphere, and moreover familiarise in some degree the art-public with our too-much neglected claims.

The collection of drawings in the galleries this year does not quite equal that of last, either in point of numbers or interest. On first entering the reverse might appear to be the case; since the sets of designs submitted for the Manchester Assize Courts, as well as one or two other competitions, are of such magnitude and importance as almost to constitute an exhibition by themselves. The great deficiency is in drawings of works of a high class now in progress, of which there are barely a dozen on the walls. Possibly these choice subjects have been reserved for Trafalgar-square; we shall see by next month.

Of these Manchester Assize Court designs there are no fewer than fifteen exhibited, and though some of these are but imperfectly represented, the space they cover on the walls is very considerable, and therefore, under the circumstances, the best has perhaps been done in giving a fair sample of each. Due honour is given to that by Mr. T. Allom, the only one of the premiated designs which has been sent, and it well merits the distinction; since, as a specimen of effective, but not over-laboured handling, there are not two finer specimens than (30, 31), which show the Gothic and Classic perspectives as arranged to suit the same plan. On the score of orthodoxy there is much to cavil at in the details of the former, but as a composition attributable to an artist's eye, it leaves nothing to be desired. The Classic design is, to our mind, as we believe it is to most, the preferable one, but the other is the one which received the second premium. Both are tinted in sepia, and are still further explained by some masterly sketches of the interior. We should have been glad to recognise the plan again, which we remember to have been very complete. The next best designs are two in ink outline only, both displaying much inventive talent, and particularly well drawn, but suggesting a question as to suitability of appearance. They are by Messrs. Norman Shaw and Nesfield (12—15), and by Mr. W. H. Cropland (1—3). The leading features in both are based on the same sources, the geometrical Gothic of the continent, and in which sculpture plays an important part. The "subjects" which are introduced into the former of these designs are conceived with masterly skill, and add great richness and beauty to the general mass. It were easy to dilate more upon these two sets of drawings, but as by this time many of our readers are already acquainted with their merits through other mediums, and as the immediate occasion of their production is now a matter of history, we shall merely invite a thorough study of their *detail* for those who may not yet be acquainted with them. Of the other designs for these Assize Courts we may notice (7), by Mr. Truefitt, as clever, but lacking the amount of talent which the works of that gentleman usually manifest; (5, 6, 26), by Messrs. Green and Devilla, very meritorious; (11 and 17), by Mr. F. Pownall, especially good; (16) by Mr. Roger Smith; and (4), Mr. Garling's Renaissance, capital of its kind.

The next most important series of competition designs is for the Guildhall at Cambridge, which elicited some very excellent suggestions. The selected design is not here, but that by Messrs. Green and Devilla (51, 52) was one of the six selected by Prof. Donaldson. In the exterior there is a certain clumsiness of effect produced by ill-proportions, while the interior has some good points, and particularly the skilful framing of its open roof. The style of architecture is unfortunately rather exceptionable. That by Mr. I'Anson (47—49) savours of the German element with which he impregnates his buildings generally, and of which his city warehouses, in Fenchurch-street and elsewhere, are so many modifications. This is the only design accompanied by a plan, which shows the difficulties of the site. (41—46), another design for the same, by Mr. J. P. Jones, has a certain boldness of treatment which is commendable, though not in the purest style of art.

The plan and elevation for a Metropolitan Hotel (27, 28), by Mr. Ernest George, which obtained the recent gold medal at the Royal Academy, are in the prevailing Venetian-Gothic style, less servilely treated than usual; great praise is due to its author for the variety which he has managed to introduce in the subordinate parts, as well as for the facility with which he has contrived subtle distinctions in portions where uniformity or balance of general outline was a desideratum.

Messrs. Hadfield and Goldie are this year in full force. The first of their subjects is (38), "Interior of Holy Cross Church, Liverpool," which deserves to have been placed on the line. As it is it might easily pass unnoticed, being very palely tinted, and above the eye: it bears marks of considerable ability in the grouping of features and apportionment of detail, as well as, in the latter especially, an agreeable novelty. We prefer it to their more ambitious production (61, 62), "Design for SS. Peter and Paul's Church, Cork," which is chiefly commendable for the boldness of its internal parts, and for its ornamental yet constructively-framed roof, consisting of carved principals strengthened by an inner rib, the intermediate space being filled in with pierced quatrefoils.

Several portions of Mr. Nicholl's design for the church at Cork (64) are not without merit, especially the detailing of the altar; the general scope of the interior does not please us so well. Of the design for a memorial clock tower to the late Sir Henry Havelock (67), the less said the better; and the same of its neighbour (69), "Competition design for West Croydon Congregational Church." Far better is (71), another competition design for a church, in which Mr. Bentley appears to have adopted for his model Mr. Sidney Herbert's church near Salisbury. Mr. Fowler Jones exhibits in (73) his design (which received a premium) for the Inverness District Lunatic Asylum. Possibly to the arrangement of the plan the author owes his success, the view is certainly by no means striking. A sheet of old architectural engravings, done in the 16th, 17th, 18th, and 19th centuries, and exhibited (78) by Mr. Harry Oliver, will be examined with much interest: there are in all seventeen, and are the production (among others) of P. Galle, 1537; Wendelinus Deterlin, 1598; Stephen de la Bella and P. Mariette, 1610; Jean le Pautre, 1617—1682; Marco Sadeler and J. Salvent; Bouchardon and Honquier, 1698—1762; Piranesi, 1711—1788; and Le Keux, 1835.

(The notice of the remaining portion of the drawings, &c. will be given in our next.)

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We are glad to observe that the Committee have followed up the custom of previous years, in instituting a fresh series of lectures to be delivered on Tuesday evenings, as heretofore, on subjects interesting to the public in general, as well as the profession. The first was delivered on Tuesday last, by Prof. Donaldson, "On the arrangement of a Roman consular house; and the every-day life of a Roman patrician." The remaining lectures on the list are as follows :—

May 1.—The battle of the styles: its past, present, and future: from a favourable point of view. By Mr. R. Kerr.
May 8.—On the comparative progress of English and French architecture. By Mr. J. H. Parker, of Oxford.
May 15.—On the application of Gothic architecture to civil and domestic buildings. By Mr. G. E. Street.
May 22.—Suggestions on architectural composition. By Mr. E. B. Lamb.
May 29.—The story of a great and good man—William of Wykeham. By the Rev. Mackenzie Walcott.
June 5.—On the discoveries of the Budrum expedition. By Mr. R. B. Pullan.

The exhibition will remain open till the 30th of June.

THE DEPARTMENT OF PRACTICAL ART AT THE ARCHITECTURAL EXHIBITION.

From the fact that several of the past years' exhibitors have renewed their "wall-space," it may be presumed that, commercially speaking, the result has been satisfactory. This is as it should be, and indeed is no more than might be anticipated, provided the manufacturer offers a fair sample of a good article. It is peculiarly the province of architects and builders to second such endeavours to the best of their ability, and now that opportunities are offered for comparison of claims previous to selection, it will necessarily stimulate each art-workman to gain the desired preference.

Among those who retain their show-space we observe Messrs. Johnston Brothers, and Hart and Son, in mediæval metal-work, Minton, and Maw and Son, in mosaics and pavements, Desachy in his papier-mache or "le staff" ornaments, Cox and Son in woodwork, and Fayle in pottery and moulded bricks. Besides these there are Martin's cement, Hobbs, Ashley and Co.'s locks, (with others by Mr. Pugh,) specimens from the London Parquetry Company, Pierce's stoves, Moore's ventilators, Cooper's paper-hangings, Ransome's artificial stone, and Mander Brothers' "Tackless" varnish, the specimen of which is the same as last year, without having received any fresh coating, nor does it appear in the least to require it. These different subjects having come under our consideration in describing the last Exhibition, it will be in the main needless to recur to them, especially since they have undergone but little revision or addition. In Messrs. Hart's metal-work however, we notice some very appropriate coffin furniture, and some elegant brass standards for moderator lamps; Messrs. Hobbs's locks appear still more perfect, if possible; and there are several fresh adaptations of Moore's ventilating principle.

The scagliola marble manufactured by Mr. V. Bellman is an excellent imitation of the originals,—the Babbacombe and Verd Antique particularly so: there is an opportunity of testing the latter by a specimen of the actual marble in another of the rooms. From statements of recent experiments on Ransome's Patent Siliceous Stone, the following results are given as to the powers it possesses of withstanding forces causing pressure and transverse strain:—two 2-inch cube blocks were crushed, one by a pressure of 20 tons, the other by 22 tons, equivalent to a pressure of 600, and 780, tons on a square foot. These experiments were conducted at the Testing-house in Woolwich Dockyard; and it has also been found (according to the same authority) that beams of this material offer greater resistance to steady transverse strain than beams of Hard York, Park Spring, Darley Dale, Portland, Aubigny, or Caen stone. The Poole Architectural Pottery Company have supplied a fresh series of specimens of paving, the patterns having been designed by Messrs. Raphael Brandon, J. M. Lockyer, &c. The mosaic pavement now laid down in the entrance-lobby to the galleries is in every respect a great improvement upon the one which it has replaced, and which was by no means a fair sample of the material. The new pattern has been designed by Mr. Brandon.

Wright's Self-acting Water-closet (4) may be again noticed, as a very complete manufacture, being at once simple and effective. Among other recommendations stated are, that it can be fixed by any ordinary plumber, and is so contrived that no effluvia can escape. Messrs. Botten have also some excellent apparatus of this kind (7); also a patent direct action compensating Gas-meter, constructed for the requirements of the Sale of Gas Act (which allows but little variation in the water-line). "In this meter there can be *no variation* of water-line, and it will continue to work correctly for years, without attention to the supply of water."

Wetterstedt's Patent Metal for roofing, &c., and Arrowsmith's solid Parquet Floors, have been before described by us. Several specimens of each may here be examined (5, 6). The same may be said of Pierce's Stoves and fire-lump grates, which deserve a wider patronage than they have yet enjoyed. (8) Cole's patent Smoke Exhauster and Down-draught Preventer is a simple contrivance of a metal flue and mouth within the ordinary flue. We presume that, like other specifics for this (we hope *not*) incurable plague, its efficacy can only be proved by actual trial. We called attention last year to Mr. D. O. Boyd's plan for attaining a like result, combined with ventilation. Messrs. Norman's specimens of Model Bricks (10) appear to be a good material, but the design of the crest ornaments and other attempts at embellishment are tame and ineffective. Chantrell and Dutch's patent economic Self-acting Water-closet, and water-waste preventer (11), combines a cheap and desirable glazed stoneware cistern, with measuring box, double-action valve, vulcanised india-rubber washers, overflow and air pipe, besides white enamelled stoneware hopper, basin, and syphon trap ball-cock, for supply; simple self-acting lever and rod; seven feet of flushing pipe, with connections to cistern, and pivot hinges for seat. Its price at Liverpool exclusive of timber-work is stated at £2. 10*s*. It is also adaptable to slate and other cisterns, and for flushing urinals, &c. Rees and Co.'s patent Pressed Glass Clock-dials for churches and other clocks, exhibited by Messrs. Moore (13), are transparent in any colours, and, being permanent, the saving of cost in regilding, scaffolding, &c. is effected. The price is stated to "bear comparison with the ordinary clock dials at present in use." They are made so as to look opaque by day, but to be illuminated at night.

There is (15) a large specimen of Wright's patent Gill Colorifier, for warming churches, public buildings, mansions, &c., and its frequent application to these purposes may be taken as some proof of its efficiency. Its principle, as is well known, is that of heat radiation by a large surface of metal plates constructed in such manner as, when rolled together, to form a cockle. The inside of the stove being corrugated, acquires heat from the fire with great rapidity, while the very great extent of surface presented by the projecting wings warms a considerable volume of air at a low temperature. It is also provided with receptacles for water, the evaporation from which is in a direct ratio to the amount of that generated by the stove, correcting the tendency to overdry that air usually complained of in hot-air stoves.

Several models in plaster, cast from *glue* moulds (18), by Mr. R. N. Haswell, will attract notice. As far as conception goes there is much to approve, but the principle of the colouring appears to us a mistake. Such works are legitimately treated only by a plain colour for the relieved ornament, and another for the ground, both painted in flat. Mr. Jennings, of Blackfriars, whom we missed last year, is again (19) an exhibitor of several domestic and sanitary inventions, the most simple and handy of which is a washing apparatus, in which the basin is supplied with water by merely tilting it backwards, while another tilt empties it with equal readiness and expedition.

Messrs. Harland and Fisher are very successful with their Paper-hangings and decorations (188). The patterns are invariably good, and the colours well chosen. This is a branch of art which, till late years disregarded, has now become one of great interest and importance; we are therefore glad to recognise from time to time progressive developments such as these bespeak. Hung close to them are Messrs. Williams, Coopers, and Co.'s specimens (192) of "Various designs in Paper-hangings," also very good, as we have on a previous occasion mentioned; they also show an "Arabian decoration," designed by W. Parris, Esq.; and an "Italian decoration." These present some agreeable combinations, but are not so generally applicable as the others.

Messrs. Minton, Hollins, and Co., and Messrs. Maw and Co., have as usual an extensive array of Mosaic and Encaustic Tile pavements, the respective merits of which are now too well known to need recapitulation. It is, however, satisfactory to observe that, in the designing of patterns, professional judgment

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has been consulted, and the names of Messrs. Digby Wyatt, Lockyer, Raphael Brandon, Ferry, Owen Jones, Goldie, and others, are quoted in the catalogue as having assisted in this object.

Smith's "Patent Ornamental Wood" is shown in (193), and offered as suitable for panellings and other architectural decorations generally, as well as a "substitute for the inlaying of pianoforte cases and cabinet work generally." This seems to be quite a novel process (at least we do not remember seeing such before); still it does not quite commend itself to our notions; the work wants that sharpness and decision of form which are ensured by the ordinary mode of inlaying. Perhaps future attempts may be more successful. It has the advantage of being of a permanent and enduring character, not being affected by damp or heat. The London agent is Mr. W. Howard, 34, Berkley-street, Lambeth.

Now that marble is so liberally introduced as a medium of surface decoration, it is gratifying to know that some of the veritable resources of the ancients are again opened for working. Among these there is none more valuable for such purposes than "Verd antique," of which splendid slab-specimens may be examined in (194). These have been supplied from the quarries in Greece, now possessed by M. Kleanthez; the prices given are 30*s.* per cubic foot for usual sizes; extra sizes, or monolith pillars, 40*s.* Orders to be addressed to Mr. E. C. Ionides, 28, Threadneedle-street. We strongly commend this fact to the attention of the profession. In a recent number of this Journal (March, 1860), we printed at some length remarks upon the qualities and application of zinc for building purposes, especially as suggested by the Vieille Montagne Zinc Mining Company, of Belgium, France, Sweden, and other countries, and the practical working of their plans may be seen (346) in their specimens and models of zinc work, stamped ornaments, and architectural features. As the recommendatory qualities of this material have been so fully explained, it is only needful to remark that the ample size of these models shows every detail as to operations most minutely.

On the table is a model of Elkin's patented improvement in Window-frames and sashes, which consists in that portion of the frame technically called the pulley-style, being made loose instead of fixed. It is kept in its place by springs placed at each end, and the face of the pulley-style is thus made to press equally against the edge of the sash. By this plan, either the top or bottom sash may be readily taken out for cleaning, or other requirements, without injuring the paint or woodwork. The pulley-style may also be easily taken out of the frame to repair the weights or lines.

In addition to the space devoted in the galleries to the practical department of the Exhibition there is a separate and extensive show-room immediately contiguous, on the ground-floor, appropriated to like purposes, under the agency of Mr. D. O. Boyd. Visitors to the exhibition will therefore do well to inspect this also, as many articles will be observed exclusively there. A handsome series of fireplaces in Magnus' Enamelled Slate at once arrest the eye. Many of these are fitted with encaustic tile jambs, and pattern-tile hearths, some of which are glazed, and some (which we think preferable) left plain. We are decidedly favourable to the introduction of ornamental tiles in such situations. The material itself is suitable, while the pattern and colours impart a degree of richness contrasting well with the bolder lines of the surrounding parts. Some of the specimens of these, as well as others in the room adapted for various styles of paving, are from Godwin's tile works at Lugwardine, near Hereford. We have before had occasion to speak approvingly of this manufacture, but Mr. Godwin appears now to have brought it to that perfection which leaves little more to be desired. As regards quality and colour they are equal to any we have seen, and their perfect flatness and evenness throughout are an evidence of the pains taken in their preparation. Such exertions deserve success, and we are gratified to know that the Lugwardine tiles are becoming extensively appreciated.

Among the remaining specimens around we observe an attractive display of metalwork from the well-known works of Skidmore, of Coventry, including a highly ornamental corona, and some very elegant gas-standards; also a number of photographs of his elaborate work in the court of the Museum at Oxford,—sufficiently large in detail to show the several parts very clearly. Mr. Boyd's own inventions, too, of course find a place here, and will be examined with interest.

ON TEMPORARY CONSTRUCTIONS.

The assertion that we in the present day habitually make those structures temporary which ought to be permanent, and build permanent structures where temporary ones are required, would seem startling and paradoxical; and if advanced without allowing for many exceptions would be untrue;—but there is far more foundation for such a statement than might at first sight appear, and we shall hope to show that, if on the one hand we have learned habitually to disregard that solidity of building necessary for the permanence and the comfort of our dwelling-houses, we have also neglected the facilities for experiment and convenience which temporary structures judiciously employed are undoubtedly capable of affording, often with manifest economy and advantage.

A temporary building is intended to serve much the same purpose as the occupation of leasehold premises: in the one and the other instance, the outlay and the delay attendant upon getting a building erected are exchanged for accommodation speedily obtained, and without sinking a large amount of capital. Probably the building is not all that can be wished in either instance, nor does it afford a permanent possession; but then, against these disadvantages are to be set the considerations that opportunities are afforded for experiment and for a change of ideas, and that should some radical modification be requisite, no overwhelming incumbrance has to be got rid of.

So large a proportion even of that class of persons who could afford to build for themselves prefer to have the power of trying a neighbourhood or a house before they settle themselves down in it, that it is a customary thing both in town or country for houses to be built and let to persons, who take the option of buying them after they have lived in them some time. These houses are in fact temporary residences, and they are, as far as occupiers are concerned, converted into permanent residences whenever the purchase of them is concluded. It is only in some such way as this that a temporary building for a dwelling-house or any purpose analogous to a dwelling-house can be obtained; but it cannot fail to be perceived that the same sort of advantage may often be procured for many public purposes by the erection of a temporary structure.

The inducements to this course have been already slightly indicated: they are first, a saving of capital; secondly, the prevention of delay; thirdly, scope for experiment and expansion; and fourthly, diminution of the loss incurred by disaster or failure. The objectionable features of all temporary structures are, first, that they *are* temporary; and secondly, that they are almost necessarily imperfect and defective. We shall refer to several instances in which temporary structures have been applied, and to various purposes which they might be or have been made to serve; and shall see how the various advantages and disadvantages enumerated above apply in each case.

A good temporary building ought to be inexpensive; if possible, its actual cost at the time of erection ought to be little; and if this is not the case, then it is indispensable that the materials of which it is composed should be such as will be saleable at but a small loss whenever the building is demolished. It is manifest however that capital is not saved to so great an extent in a temporary building where valuable materials are employed as in one where the materials are almost worthless, supposing the latter to have cost less originally than the former. It is further almost always essential that a temporary building should be such as can be rapidly built and as rapidly cleared away; and lastly, it is necessary that it should answer most of the *practical* ends which the permanent one will answer, and that in a tolerably successful manner.

Perhaps no better illustration of the subject can be chosen than the greater part of the system of railway works in America presents, as compared with those of our own country. No works, to answer the purpose, can be more temporary in their character than the generality of American railway works;—none more solidly permanent than those on our own lines: and the difference bears out the preliminary observations just made respecting the saving of capital and time. Capital has not yet accumulated in the United States as it has in Great Britain, and the means of conveyance by canals and roads do not exist in that wide and sparsely peopled country which we enjoyed at the time we commenced our railways; consequently to save capital and to save time were of vital importance to American engineers, and their works have accordingly been hastily and cheaply done. No

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doubt in many places the annual repairs will be high, and much of the work on some of the lines will in time have to be done over again; but in the meanwhile the desired end has been accomplished, new districts have been opened up, and that with rapidity, and without exhausting the capital resources; and consequently the country has been so enriched that even if the ultimate cost of many of the lines, after double lines of rails have been laid throughout and timber viaducts are replaced by structures of stone and iron, equals or surpasses the cost of many of our own railways, it will be easily met.

In the meanwhile the Americans possess, with their cheap railways, facilities for altering and amending their system which do not exist in this country. If an improved line can be traced the adoption of which would necessitate that part of an existing railway should be abandoned, the less costly this line has been the less difficulty there will be in deciding that it shall fall into disuse. If the success of some proposed railway be problematical, the cheaper the construction the less difficulty will there be in making the experiment; should an experimental line thus cheaply constructed develope a great traffic, there would be far less difficulty in raising capital for a permanent work than if the experiment had not been made; and lastly, should discouraging results be experienced, the loss will be less the smaller the expenditure.

The time is however almost past for the possibility of temporary railway works in Great Britain, and yet it is difficult to abandon the subject without referring to terminal stations, as more often than not suitable for temporary structures.

It is always difficult, and usually impossible even if desirable, to alter the situation and arrangements of a road-side station, these therefore it is best to make permanent structures at once; but experience has shown that circumstances often arise which make it desirable to alter the position of a terminus, either to prolong a railway, or to effect a junction with some other line, or to run into some common station from which several lines may start: and further, alterations of arrangement and extensions of all sorts have so often proved needful, that it would seem always wise to reserve the building of a permanent terminus, as an undertaking best completed some years after the other works on a railway are finished.

This plan has been pursued by several of the lines of railway that end at the metropolis, and yet not so extensively but that we have seen at London-bridge one costly and ornamental building demolished and rebuilt; and are in all probability likely to witness the disuse of one or two at least of the present metropolitan termini, from which lines of railway will be continued on towards the centre of the metropolis.

One of the most appropriate applications of the principle of provisional buildings is to church-building. The first essential for a place of worship is a body of persons to worship there, and for collecting these and giving them an opportunity to organise themselves, a temporary church is an admirable auxiliary. It is not the province of a professional journal to attempt to point out to religious bodies what course it is prudent for them to pursue, else it would be easy to say a great deal in favour of this way of collecting the congregation who are to make use of a proposed permanent church, and whose liberality will in the main have to raise and support it. Schools are at times commenced in a similar manner; and in the case alike of schools and churches, and also of all other institutions which are to depend on popular support, whenever it is doubtful how far that support is to be relied on, the expedient of beginning in a temporary building affords a method of arriving at certainty.

A temporary church may probably have to stand and be occupied for several years, and therefore ought to have considerable solidity. Temporary rooms and theatres are at times required which are only wanted for very short periods: these may therefore be built comparatively slight, yet with every precaution to prevent danger from accident or panic. It sometimes however happens that such rooms create a want that was hardly expected to arise, and thus render a permanent structure needful. The Free-trade Hall at Manchester was an instance of this; originally run up very rapidly and inexpensively to afford a gathering place for the vast assemblages that used to meet upon the corn law question, it seemed doubtful whether a permanent need for so large a building would exist. The hall however became and continued popular, and remained in constant use, till it was at last decided to take it down and rebuild it. This has been done, and the present handsome structure is an admirable instance of the advantages that may arise from the system we are now advocating.

It has been however reserved for our own day to develope a new species of requirements, which claim to be met by an extensive yet ephemeral class of structures, as novel in their construction as in their destination. The system of provincial and national exhibitions led to the proposal of that great international exhibition for which just ten years ago preparations were actively in progress. We all know how inadequate the methods previously practised proved to meet the requirements of the case, and how successfully the difficulties were overcome in the Crystal Palace. Since which we have had the buildings for the Dublin, the New York, and the Manchester exhibitions, erected more or less in the same style and with the same materials, namely, iron and glass; and, to quote but one further instance, at Kensington-gore we have an example of a temporary iron building, at first of very inexpensive character, being made the nucleus of a large and constantly increasing range of buildings of a permanent nature, till at last the original iron building will itself, no doubt, be transformed into a handsome and solidly constructed museum.

In what way and of what materials ought temporary structures to be made?—is the next question that requires notice. Till lately timber in some form was almost the only material deemed fit for such a purpose, and now, though other materials are much used, timber can in most cases compete with them successfully. Brick is sometimes partially employed for walls—concrete and even earth might be. Iron and glass of course must be included among available materials, and corrugated iron, zinc, felt, and some other substances are largely employed.

In many cases however the best groundwork for a temporary building is old houses. Nothing else would be found dry enough, warm enough, and solid enough for a provisional hospital, infirmary, asylum, or poor-house;—and, where the floors can be cut out with safety, an old house gutted makes a very good temporary church. Too much caution however cannot be employed to prevent danger and accident; and where the structure is much out of repair, or the alterations requisite are extensive or complicated, this resource had better be given up.

Corrugated iron has been much employed lately, and buildings erected with it have the advantage of being very quickly put up or demolished. The material, nay, often the entire building, will also fetch a good price after being used, but consequently this mode of construction has not the advantage of an extremely low original outlay. An iron church is also liable to be hot in summer and cold in winter, to a greater extent perhaps than one of wood, though all temporary buildings partake of this defect: there is also some liability to noise from rain and hail. Houses and churches of iron are however very much in use for some purposes, being even exported occasionally to the colonies; they possess the advantage that one of them can be bought of the makers at a fixed price, ready for instant use, and transported with dispatch to the spot where it is wanted, and quickly set up.

Timber has long been employed in these constructions, and is deservedly popular, both from the ease in which it can be worked and fixed, and the value which it retains after careful use. In fact, were it not for the risk of fire—which may be neutralised, perhaps quite got rid of by Kyan's process—timber buildings, weather-boarded at the sides, and covered with asphalted felt, would seem as advantageous as any. A very cleverly constructed church of this kind stands near Tuffnell-park, Holloway, erected by Mr. Truefitt; and another capital example for an economical timber building, though finished in a superior style and slated, is to be seen in the present Pimlico terminus of the Crystal Palace Railway.

It would be desirable in such buildings to follow some plan similar to that pursued for the sake of warmth in the wooden houses of Norway. In these the walls are made with an outer and an inner inclosure of wood, having a space between of some inches, which in itself would promote comfort, since a layer of air is a bad conductor of heat. This space is well filled in with dried moss, as a substitute for which we might in this country employ hay, straw, or shavings, any of which would prevent both wind and cold from penetrating.

A frequent error in such structures is making them of unnecessary strength, and employing pieces of timber upon which nothing but tension is exerted, instead of which it would be better to employ iron rods, the ends of which might be a little

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twisted round the pieces of timber which it is wished to secure. In calculating the strength of these timbers it will be enough to make it quite certain that none of them will break under their load: that some of them should receive a "permanent set" would be a matter of very little moment.

A very good illustration of the adaptability of timber to purposes of temporary construction may be seen in the great Handel Orchestra at the Crystal Palace. This orchestra is entirely supported by short and light timber, put together in a manner thoroughly temporary, and was built in a short space of time. It is however steady and strong, althongh it could rapidly be cleared away if wished, and when full of persons necessarily supports an enormous weight.

Without attempting to analyze the entire economy of a temporary building, or to give a set of rules for its construction, it may be possible to point out one or two characteristics that have appeared in most good constructions of the sort, and to name one or two principles which seem to apply pretty generally to the arrangement and erection of them.

If the expense of the erection is to be diminished by the sale or employment of the materials after they have served their purpose it is pretty obvious that they should be as little injured as possible, should be selected of sorts that are likely to be in demand, and should be preserved in sizes and forms such as will not be useless for other purposes; while on the other hand, as none of the labour can be recovered, it seems important to arrange that there shall be as little labour as possible expended on the erection, and that as far as possible that labour shall not need to be done entirely by skilled artizans. All this requires no small amount of contrivance, and in arranging it there is great scope for the display of the mastery of mind over matter. One intelligent and skilful engineer may save, by a day's careful study and painstaking calculation, the manual labour of many artificers working for many weeks, with of course a corresponding economy of funds.

Whether timber or more solid materials be employed, a great secret of arrangement is to avoid many sizes, and complicated joints. The Palace of 1851 was, it is well known, designed so that a very limited number of different castings were employed throughout the whole work, and the connections were of the simplest kind, so that in a few minutes after a column was in its place the girders could be fixed to it; and as the columns were all alike, and the girders almost all alike, and the length of bearing the same every way, no time was lost in seeking for the proper piece to put into any given place.

Perhaps another point as important as those referred to, is the desirableness of employing the materials to be found in the locality, and, if possible, the methods of construction practised there;—the one saves carriage of materials; the other prevents the necessity of bringing men from a distance, and often too, if the local materials are peculiar in their qualities, makes use of them to the best advantage.

These observations as to materials and construction of course apply chiefly to small or moderate sized buildings The crystal-palace mode of construction in iron and glass does not come within the reach of those putting up provisional buildings for ordinary purposes, as it would probably be found costly if employed in small quantities, and unless the work be well done is liable to leakage; but it is the cheapest and most readily erected of any known construction where a large building is required, and in all such cases will probably for the future form the basis of whatever method is adopted.

Brickwork is ordinarily too expensive for our present purpose, and when pulled down the bricks are often worth but little. Brick foundations, and even walls, are however sometimes employed for temporary purposes. The concrete walls, of which some were used at Aldershott, and the mud walls of the west of England, seem to be worthy of consideration, in localities where the materials are at hand and their use is understood, as they are solid and warm, and could be rapidly and inexpensively built.

In leaving this subject it seems desirable to suggest one or two uses to which structures not intended to be permanent might be put—and these are of the nature of experiments. In bridges, especially foot-bridges, landing-stages, and many hydraulic works the income from which is uncertain until they are actually in use, the preparatory works, especially if they include a coffer-dam, are very solid, and hence very costly. Might not these works be so arranged as to be themselves made use of for some years, so as to demonstrate the advantage or otherwise of the proposed permanent work?

Again, in cases where the perfect transmission of sound is of greater importance than anything else, might it not be a wise policy to form the interior of a hall or room or court of justice in a temporary way—without decorations, with a moveable ceiling, and preserving a means of altering proportion and height, till the form most favourable to sound be attained? Something of this sort was done at the Houses of Parliament,—why not in such a building as the Assize Courts now in progress at Manchester? It is not very unusual for a clergyman, when preaching in a newly-erected church, to occupy a temporary moveable pulpit; and if this practice of making experiments were universally instead of occasionally adopted, it cannot be doubted that acoustic defects, which in many churches arise from the pulpit and desk being in unsuitable places and at improper heights, would at times be discovered and remedied, without either the discomfort or the expense which errors of this kind often entail.

One other mode of experiment that has long been known to architects, but which can never be too much commended to their attention, is the mode of studying important exteriors and interiors by means of models, either full size, or made to scale, and elevated to such a height as will bring the eye of the spectator to the right proportionate level. This affords a means of testing effects which cannot be altered after the building is once up, and of discovering faults which then perhaps would have become irremediable; indeed, the model affords to the architect of taste and skill the same advantages in carrying out a work of art which a temporary building does when embodying a practical idea; it affords him a means of experiment and an opportunity for modifications, at a period when the results of the experiment will not arrive too late to be of value, and when it will still be possible for any modifications which may be found advisable to be embodied in the permanent structure.

MANSION, STRATTON AUDLEY PARK, OXFORDSHIRE.

(*With an Engraving.*)

This mansion, the south front of which is given in our illustration, is now in course of erection at Stratton Audley, near Bicester, Oxfordshire, and is expected to be completed in the autumn of this year. The site selected is a peculiarly happy one, on the summit of a gently rising slope, affording extensive views to the south, west, and south-east, while on the north the house is sheltered by well-grown trees, and is approached through an old and handsome avenue. The entrance is from the north, and the principal apartments are grouped round a lofty entrance-hall, which also contains the principal staircase. They comprise a library, and billiard-room, 22 ft. 9 in. by 17 ft. 6 in., with windows to the north and west, and a square bay. A drawing-room, 28 ft. 9 in. by 18 ft. 9 in., having windows to the west and south, including a semi-octagon bay; a dining-room, 29 ft. 9 in. by 18 ft., with a south aspect; and a breakfast-room, 16 feet by 18 feet, with windows to the south and east, and opening into a conservatory. All these rooms have a height of 13 ft. 6 in. in the clear; beyond them are placed servants' hall, housekeeper's and other rooms, kitchen and kitchen offices, laundry and washhouse, and, in a detached building, stabling and coachhouses. The bed and dressing rooms on the first floor have a clear height of 11 ft. 6 in., and those on the upper floor of 10 feet. The cellars are the only portions of the house on the basement.

The materials employed are, for the rubble-work a local limestone, of a fine blue colour; and for the dressings, Box-ground Bath stone: the internal work is all executed in brick. The limestone has its face left, showing the natural cleavage, which affords an endless play of light and shadow, imparting an interesting variety to the surface of the masonry, far beyond any effect that dressing would produce; the beds and joints are carefully squared, and the stone laid in regular courses, but of varying heights. Masonry of this description is more common in the north of England than in the south, its introduction in the present instance has been attended with marked success. As this stone is slow in parting with the moisture it has imbibed in the quarry, a lining of brickwork has been thought necessary, connected with the masonry here and there by bond-stones and brick-headers, but elsewhere with a space of 3 or 4 inches be-

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tween them. The roofs are covered with tiles of a red colour, with a black tile cresting.

The method in which the works at this house are being carried on is one less usual at the present day than a generation ago. No general contractor is employed, the proprietor purchasing such materials as the estate does not afford, and employing his own workmen, placed under the orders of an experienced foreman, and directed by the architect. Rarely have the local resources of any estate been more successfully explored and brought into play than by the proprietor of Stratton Audley Park; besides the rubble-stone already alluded to, which is quarried within a mile of the house, the whole of the bricks and roofing tiles, and tubular tiles for flues, have been made; the whole of the sand and gravel for mortar and concrete have been dug, and the whole of the lime has been burned, within a short distance of the house itself, and within the limits of the property; from which has also been obtained all the material for scaffolding, a large proportion of the oak timber employed, and elm, black poplar, and some other varieties of wood, which have been made use of where practicable.

The conservatory, and a drying closet connected with the laundry, together with the hall and corridors, are heated by a system of hot-water pipes at low-pressure, arranged and supplied by Messrs. Grange, of Uxbridge; this apparatus also supplies hot water for a warm bath, and draw-off cocks on each floor. The ornamental metal finials, which are very good specimens, are executed by Skidmore, of Coventry.

The architect is Mr. Roger Smith, of 57, Strand, London; and the resident clerk of works and foreman Mr. Joshua Lewis. The grounds and gardens are being laid out under the direction of Mr. R. Marnock, of the Regent's-park Gardens.

RICHMOND CHURCH, YORKSHIRE.

This important ecclesiastical structure and its noble site form great attractions to the locality of which it is so distinguishing an ornament. From the very circumstances of its foundation, however, the fabric had for some time shown symptoms of insecurity, until it was at last resolved to place the whole in a state of thorough repair, and also to refit the interior in a becoming manner. This has now been accomplished, and the church, which was closed previous to these operations on the 30th of Nov., 1858, was reopened on Easter Tuesday.

The church possesses several features worthy the attention of the archæologist, carrying him, as he passes along its aisles, through almost every period of English architecture. In the west end of the nave are two arches in the Norman, or to speak more correctly, in the transition style, in which the massive pier of the earlier date is surmounted by a pointed arch, denoting a later period. These, with the characteristic north porch, are the only vestiges of what appears (from other remains disclosed by the demolition of the old building) to have been, at this early period, an extensive and handsome church, with a clerestory lighted by three circular windows on each side.

These remains have been, as far as practicable, preserved in the late restoration, but scope has been left to the architect, Mr. Scott, in many alterations and additions which it has been thought advisable to make. The east window has been slightly increased in length, though its proportions will bear no comparison with the elegant west window—a beautiful specimen of the Perpendicular style. The internal arrangement of the building has been also recontrived, and the nave extended twenty feet, which have been taken out of the chancel—thus placing a much larger portion of the congregation in front of, instead of behind the pulpit. The chancel posesses a rich treasure in the beautifully-carved oak stalls, originally belonging to the neighbouring abbey of Eastby:—these have been carefully restored, and two others added. The pulpit is of stone, and comparatively unenriched. The font, of Eggleston marble, was, until lately, covered with paint, on removing which it was discovered that a pedestal of sandstone had been substituted for that of marble.

The galleries are as simple and unobtrusive in design as possible, and by no means unsightly: nor would it be fair to pass unnoticed the very excellent wood-carving throughout, in which natural foliage is freely handled and in great variety. This has been executed by Messrs. Shaw and Young, of York, while the stone-carving, which is equally meritorious, is by Farmer, of London. Several of the windows have been filled with stained glass by Mr. O'Connor, and others by Clayton and Bell. The gas standards, from Skidmore of Coventry, are elegantly proportioned: they are divided into four branches, those in the chancel being surmounted by a corona in addition to the branches.

The pitch of the new roof is higher than it ever was at its earliest date. The aisles are covered with lead, as before, and the chancel and nave with Westmoreland slates.

The entire cost of this work, exclusive of the windows, is calculated at little less than £6,000.

CONTINENTAL PUBLICATIONS AND INTELLIGENCE.

It is intended under this head to give occasional notices of one or two of the leading professional journals published on the continent, as often as they appear to contain intelligence of a nature calculated to interest our readers; in this way it is hoped we may be able to indicate the progress of invention and of public and private works in foreign countries, briefly, but in a practically useful manner. It is also contemplated, since many of the most valuable works on professional subjects are published in France and Germany, and are not always as much known in this country as they deserve, occasionally to give an account of the nature and contents of other new publications, and even of such standard works as may with advantage be consulted at public libraries, or purchased. Periodicals form, when well conducted, valuable works of reference, but in giving occasionally some description of other works of importance published on the continent, we hope to interest English readers by giving to those of them who have not access to collections of foreign works, or who are not familiar with foreign languages, some acquaintance with the continental literature of the day, as far as it bears on architecture and engineering; and by indicating books where information on such subjects is to be found to those who have opportunities of consulting them for themselves.

The *Encyclopedie d'Architecture* is a monthly journal, published in Paris, and which has now reached its tenth year. Each number contains only eight pages of letterpress, slightly larger than our own page, and is illustrated by ten plates very finely engraved in line, folded plates when they occur being reckoned as two. The contents of the work are of course very various in character, and the letterpress is often entirely taken up with notices of the events of the day. The plates form a valuable series, as the illustrations of past years comprise complete sets of drawings, from general plans and elevations to details and decorations, of many of the most interesting buildings in France, modern and ancient, mixed however with much of no value at all to an English architect. The numbers for January and February of this year contain illustrations of the Palais de Justice at Paris, showing additions that are being made in that semi-Greek style of architecture that is so successfully practised by the French architects, also various illustrations of works executed in the inferior styles of the 17th and 18th centuries; illustrations of a very fine example of the halls of the 15th century, the Palais des Dames, at Poictiers; two illuminated letters from manuscripts of early date, given in colours; and lastly, a plan and details of a small and graceful pavilion of rather late Gothic work, from the old shooting-ground at Dijon, established for practice, not as now with the rifle, but the harquebus. This enumeration will serve to show the character of the illustrations supplied, descriptive letterpress is however often scanty and sometimes wanting, or not given in the same number as the plates; and in the case of interesting buildings the illustrations are often very numerous, and spread over many months.

The letterpress of the two numbers now under notice is almost entirely taken up with reports and intelligence of various kinds, and brief notices of books, and is without any original articles, except a biographical notice of a deceased architect, M. Bouchet. Condensed reports of legal decisions on matters connected with buildings are given regularly, and the form of them as contrasted with such reports in English papers illustrates the difference between the customs of the two countries in the mode of conducting legal business. The decisions are given in these accounts at full length, either with no report of the previous evidence or with the very briefest possible statement of the nature of the case; the reason being that it is customary for the written decree of the court to recite consisely, as a sort of preamble, the circumstances of the case and the reasons which have led to the decision arrived at. Prefixed to each case is a short statement, printed in italics, of the exact bearing as a legal precedent of the decision about to follow, a plan that seems very advantageous and worthy of adoption.

Among the intelligence is an announcement of general interest relative to the near completion of the new flèche at the Cathedral of Notre Dame, one of those works for the restoration and embellishment of that cathedral which have been lately prosecuted with much energy. This flèche, we are informed, is now entirely free from scaffolding, so that its effect can be judged of: it stands over the intersection of the nave and aisle, and is octagonal on plan, having a width of 7 mètres (23 feet) at the base, and a height of 45 mètres, or 147 feet, from the main roof to the top of the cross which surmounts it. It is entirely constructed of Champagne

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oak, and covered with lead, and consists of a closed lower story to lift it clear of the roofs, two stories pierced with lights and the floors of which are accessible, and the tapering roof. Among the enrichments referred to are ornamental crockets, capitals, gurgoyles and friezes, and four large flying buttresses.

An extract from a report read by the Prefect of the Seine to the municipal council of Paris, upon the architectural staff employed by the city of Paris, contains information that has some interest for general readers. From this document we learn that the city of Paris "possesses no fewer than 715 buildings or district establishments, without reckoning 181 houses of which it is owner, the number of which varies according as purchases are made or tenements pulled down. The Hôtel de Ville, the Palais de Justice, and the Prefecture of Police, the Sorbonne, the Bourse, the Custom House, the Entrepôt, the warehousing granaries, the central markets, 70 churches or temples (protestant churches), 23 mairies or courts for 'juges de paix,' 9 university establishments, the great schools of medicine and law, 250 elementary schools or refuges, 17 barracks, 37 guard-houses, numerous stations, 10 prisons and houses of detention, 23 markets or market-places, 10 shambles (abattoirs), 18 cemeteries, 66 city gates, 144 *octroi* offices, form a long list of buildings to be maintained, or restored or enlarged, or completed; and many other new erections are already in prospect or will become necessary in the course of time."

It appears that under the arrangements followed up to the present day, the maintenance of these establishments has been committed to the care of a body of officers, 37 in number, paid a small salary, with liberty to practise on their own account: a second body of surveyors exists having the duty of enforcing the regulations of the city relative to frontages, and projections of new buildings, and whose functions must resemble closely those of the district surveyors of London; these are paid in the same way as the officers of the department for maintenance of public structures. All new buildings however have been hitherto executed by architects whom the city authorities employ only for each individual work, and to whom they pay as commission a per-centage regulated by a descending scale, of a remarkable nature. Under them are placed officers paid at a low rate, and not exclusively devoted to the service of the department. The scale of per-centage just referred to is as follows:—"3 per cent. on the first hundred thousand francs (£4000) spent within one year; 2½ per cent. on the next similar amount; 2 per cent. on the next, and so on down to a minimum per-centage fixed at two-tenths," equal to four shillings per cent. This plan has not been found to answer, and certainly unless the amount of assistance placed at the disposal of the superintending architect were very great, the portion of the scheme just detailed must have been a great impediment to the satisfactory performance of the duties, particularly in the case of large or difficult works. It is now proposed to form a staff of permanent officers, paid an adequate salary, with the prospect of a retiring pension, and obliged to relinquish all private practice. A city architect is to be appointed to preside over this body, who will have under him a body of "architects-in-chief," each taking one class of buildings only; and, forming a subordinate body under the direction of the architect-in-chief, there will be sub-architects, surveyors, and clerks of works. Not merely are the repairs and alterations of existing buildings to be superintended by this staff, but all new buildings to be erected in future for the city of Paris will be designed by the architect-in-chief into whose department the nature or destination of the proposed building introduces it. The gross annual amount of the salaries proposed to be paid to the officers employed on maintenance of buildings and new works of importance is 255,000 francs or about £10,000 per annum, but the number of persons to be appointed, and the salaries to be paid to each is not given; it is stated however that the annual expense under these two heads has averaged 315,000 francs or £12,600. For the survey and inspection department as re-organised 300,000 francs or £12,000 are allowed; the existing system requiring a still larger sum of money annually.

SOCIETY FOR THE ENCOURAGEMENT OF THE FINE ARTS.

Among the distinguishing characteristics of the present age, one of the most striking and gratifying is the taste for the fine arts which has sprung up, and is gradually spreading amongst all classes of the community. This tendency to elevated and ennobling themes is not restricted to any one form of development. The arts of Music and Poetry, as well as those of Design, are equally cultivated, almost in association; and their professors, instead of the neglect and privation which in former times were their common lot, now derive substantial reward as well as distinguished honour from the public at large.

Until, however, the establishment of the above society, more than a twelvemonth ago, no attempt had been made, upon an organised plan, to direct and improve this new intellectual development; but we are rejoiced to find that its aims are now well understood, and its endeavours warmly seconded. The primary object of the society is to create a true sympathy between artists and those to whom they minister; to elevate the aspirations of both in the mutual relations so established; and generally to promote the instructive influences of art, and its interests as a profession. These ends are sought to be attained in various ways, but principally through the medium of exhibitions of painting, sculpture, &c., of ancient and modern art, lectures, discussions, conversazioni, classes for study. To these it is proposed to add a permanent collection of engravings, and a library of reference illustrative of the fine arts in all ages,—a periodical publication connected exclusively with the objects of this and kindred societies,—photographic *fac-similes* of rare and interesting productions in art of all kinds,—and an aid-fund for affording temporary assistance to young artists in the prosecution of their studies or early works. It should be added that the subscription is one guinea a year, and that the several departments of art are represented in the list of patrons and council by many influential names.

In proof of the friendly feeling evinced towards the society by those professionally connected with the arts, the Hanover-square rooms, the French, the Suffolk-street, and the Portland galleries, with the rooms of the Architectural Exhibition, have been lent gratuitously on the evenings of the conversazioni, when, in addition to the pictorial attractions, there have been added those of music, by various artists who have given their services without remuneration.

It is proposed, in the course of the present year, to give two prizes in honour of painting, and one each in sculpture, architecture, music, poetry, and engraving.

The rooms of the society are at 9, Conduit-street, Regent-street, where the Secretary, Henry Ottley, Esq., will be glad to afford any further information that may be desired. We cordially wish the enterprise increasing success.

ON A NEW CONSTRUCTION OF HIGH-PRESSURE STEAM BOILER.*

By J. Frederic Spencer.

(*With Engravings.*)

Among the various boilers that have been constructed for generating steam of very high pressure, the small tubular form has been chiefly adopted, as being the strongest with the least weight of metal, and as also possessing the additional advantages of affording the largest heating surface in a given space, and containing almost a minimum quantity of water. One of the most important functions of a steam boiler is regular, uniform, and constant circulation of the water; so that as soon as the steam is formed it shall pass without delay into the steam chamber, and the space it occupied be immediately refilled with water. If from any cause this natural action is impeded, two injurious consequences result, namely, reduced evaporation, and premature destruction of the conducting metal. It has been found that in land and marine boilers, in which there is always such a large amount of water in the boiler compared with the quantity evaporated, there is generally a very defective circulation, as evidenced by slow evaporation and rapid destruction of the conducting metal. In generating steam within small tubes containing a small amount of water, any deficiency of the feed may leave the tubes without water, in contact with a high temperature, and stop entirely or partially the proper circulating action so necessary in generating steam. The uncertainty of what may be termed natural circulation led to the invention and introduction of that which forms the distinctive feature of the boiler now to be described—mechanical circulation: by which ten to twenty times the quantity of water required for steam may be passed through the boiler within a given time.

The new boiler is shown in Figs. 1 and 2, Plate 13; Fig 1 is a vertical section through the furnace and steam receiver, and Fig. 2 is a back elevation with part of the tubes in section. Above the furnace F is arranged a series of tubes T, of about 1 inch or 1½ inch diameter and of any convenient length; these tubes are inclosed within a brick casing, or if preferred a water space casing, square in plan; they are covered in at the top by the uptake and chimney. Alongside and secured to the casing is the cylindrical steam receiver R, connected direct to the upper portion of the tubes by the pipes L, and to the lower portion of

* From a paper read at the Institution of Mechanical Engineers.

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the tubes by the pipe E, the circulating pump P, and the pipe G. The boiler is divided into six distinct vertical sections, as shown in Fig. 2, each of which is separately connected below to a common feed or circulating pipe C, communicating direct by the valve box V and pipe G with the circulating pump P, and above to the receiver R by the pipes L. A pipe H is also fixed between the receiver and the common feed or circulating pipe C, to allow the water in the receiver to pass into the tubes when the pump is not working, and in starting the boiler.

The tubes and receiver are in the first instance partially filled with water pumped in by hand, as in other boilers, the communication between the lower and upper portions of the tubes and the receiver being open: the fire is then lighted, and as rapidly as the steam is generated in the tubes it passes through them into the receiver, until the whole of the water is heated, and sufficient steam is generated to work the circulating pump. This pump, worked by a steam cylinder, is double-acting and of simple construction, having instead of the self-acting valves a D slide valve, without lap and worked by an eccentric, so that its continuous action can be thoroughly relied on; this arrangement has in practice given every satisfaction. It will be evident that a small amount of power is required to work the circulating pump, since the pressure is almost equal on each side of the piston; so that whether this pressure be 100 or 500 lbs. per square inch, only the friction of the water has to be overcome in effecting the circulation. A boiler of 100 nominal horse power would require a circulating pump of only 7 inches diameter and 12 inches stroke, making 50 revolutions per minute. In addition to the circulating pump there is the ordinary feed pump attached to it, to supply the deficiency caused by the evaporation; and the ordinary feed pipe may be connected either to the circulating pump, as at I, Figs. 1 and 2, or to the pipe C, or to the receiver R. The water gauge is fixed on the receiver, and indicates the amount of water therein for the regulation of the feed. As soon as sufficient steam is generated to work the circulating pump, which in ordinary cases occupies about 20 minutes from cold water, the full working action of the boiler commences; and supposing 10 cubic feet of water are evaporated per hour, about 100 cubic feet are passed through the circulating pipe C and the tubes by the circulating pump. This 100 cubic feet per hour is discharged from the upper portion of the tubes into the receiver as mixed water and steam, the water falling to the bottom of the receiver and the steam remaining in the upper portion or steam space. It might be supposed that the steam would not be separated from the water with sufficient rapidity, and that very wet steam would be supplied: but practice and experience have proved that this is not the case; the separation is both rapid and distinct, and even when the water in the receiver has been allowed to rise to within a few inches of the top, the steam obtained has been quite as free from water as that usually supplied by ordinary land boilers.

Each section of the boiler has its own separate connection with the receiver, and also with the common circulating pipe C; and the flow of water through the latter connections is regulated to any extent either by simple contractions or by cocks or valves; the contractions however are preferred. There are also cocks or stop valves on each of the upper connections to the receiver, so that any section of the boiler may be shut off in case of injury, without in any way affecting the efficient working of the remaining sections. This is a most important feature of safety, and provides for easy repair either at the time of injury or at any subsequent period when convenient.

Figs. 3 and 4 show detail of the tubes to a larger scale; they are screwed with a right and a left-handed thread so as by one movement to draw the two end bends together, and by this plan the union of the tubes in each section is performed without difficulty. It will also be noticed that each section of tubes can expand to any extent, being suspended on the vertical plates S by a small lug on each bend rivetted to them. For sweeping, cleaning, or removing any one of these sections, hinged doors D are placed in front of the boiler, thus giving easy access at any time to any portions of the tubes. These boilers have been made both with brick casings and water-space casings; but the former plan is preferred on account of economy of first cost, safety, and improved combustion: when the casing is a water space, it may form the receiver.

The general construction and working action of the boiler having been described, a few remarks may be added as to its safety, durability, and economy.

Safety:—There can be no question of the great strength of small cylindrical tubes of 1 or 1½ inch diameter; and as the receiver is not acted on by any higher temperature, it can be maintained in full strength for an almost unlimited period. In consequence of the small amount of water in the tubes but little injury could arise from their giving way; and the receiver, being removed from any external source of heat, could not in the event of its bursting produce the dangerous percussive action resulting from the sudden release of highly-heated water in a heated flue. Another element of safety is the facility with which any injured section can be disconnected from the rest of the boiler.

Durability:—The only part of the boiler subject to great heat is the lower portion of the tubes, and it will be readily seen that the strong current supplied by the circulating pump tends to prevent not only deposit, but also any injury arising from want of water in the tubes. The tubes in one of these boilers that had been in constant work for eighteen months, with water largely impregnated with lime and other impurities, were found on examination of several of them to be perfectly free from scale and any solid matter passing into the receiver from which it was easily removed. In order to ascertain the effect of working the boiler with salt water, some experiments have been made with one constructed in Newcastle by Messrs. Hawthorn. This boiler was formed of wrought-iron tubes, 1 inch inside diameter, and had about 340 square feet of heating surface and 9 square feet of grate surface: it was kept in constant operation for fourteen days and nights under a pressure of 80 lbs. per square inch; with salt water having about 5-33rds or 15 per cent. of salt in it, a saltness greatly in excess of that considered safe in marine boilers. Upon examination the lower tubes were found with an internal scale 1-16th inch, whilst in the upper tubes a scale was hardly perceptible. The experiment was made with the view of trying how much scale could be deposited under the most unfavourable circumstances; and the result clearly proved that, with the ordinary saltness in marine boilers, the system of mechanical circulation would enable these boilers to work safely for a lengthened period. Although it is not intended at present to recommend the boilers to be continuously worked with sea water, it is satisfactory to know that, when used in combination with surface condensation, any temporary cessation of the pure water supply cannot injuriously affect them.

Economy of Fuel:—It is well known that efficient combustion, thin conducting metal, large heating surface, and regular circulation will give a large evaporative duty. The result of some experiments made in the United States in June last gave an evaporative duty of 11 lb. of water per lb. of fuel: it is however but fair to state that these experiments were made under unfavourable circumstances as to the working of the boiler.

Economy of Weight:—It is in marine boilers especially that weight is objectionable; and an ordinary marine boiler with 2000 square feet of heating surface is here compared with one of the same heating surface constructed on this tubular and circulating plan:—

	New boiler.	Ord. boiler
Weight of boiler, including brickwork, without water	22 tons	20 tons
Weight of water in boiler	2	19
Total weight of boiler and water	24	39

It will thus be seen that 40 per cent. of weight is saved; and in this comparison the heavy brick casing of the new boiler has been included, together with the receiver and connections.

Economy of Space:—Taking again the new boiler with 2000 square feet of heating surface, and an ordinary marine boiler having the same heating surface, the spaces occupied are as follows:—

	New boiler.	Ordinary boiler
Floor area	80 square feet	130 square feet
Cubic space	960 cubic feet	1560 cubic feet

This comparison is greatly in favour of the new boiler, showing a saving of nearly 40 per cent. both in floor area and cubic space occupied.

Economy of Cost and Repair:—As to the cost of construction, experience has proved that in all cases the new boilers with circulating pump and receiver complete are made at a less cost than those of the ordinary tubular construction; and with reference to the cost of repair, it is almost entirely confined to the tubes and brick casing, and therefore connot be serious in amount.

One other advantage has to be referred to in these boilers in comparison with those in general use: namely rapidity in raising steam from cold water.

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MODERNISM IN ART.*

By C. F. Hayward.

It might seem desirable, in commencing the few remarks I am about to make on Modernism in Art, to define the term before I proceed to discourse upon it. But I prefer to leave the preface till the last; or, if you have not perfectly comprehended all that I mean by the term at the conclusion, we will discuss the matter, and endeavour to obtain some definitions of it. M. Montalembert, in his celebrated pamphlet, speaks somewhere of the study of "contemporary archæology;" and this I cannot help fancying is a phrase intended to convey such notions of the value of the observation of daily life and present circumstances and living history, which I would endeavour to include in the term I have chosen.

The study of antiquity is enforced in a variety of ways at the present time, although the period chosen is somewhat changed—Classic to Mediæval lore. Societies in every county, and amateurs without number, devote themselves to the collection and contemplation of the minutest relics, often overlooking in the study of a detail the more broad and comprehensive objects of research, and caring less for the beautiful and suggestive than for the more curious and aged. It has, however, been reserved for a French idea to form a political society for the sole purpose of studying and contemplating ruins,—renouncing any interest in the present, acknowledging only one duty, and that, the support of an effete piece of archæology which happens to be contemporary.

To the artist however, and especially to the architect, the study of antiquity is necessary, not only to form his ideas, but to stimulate them; not only to awaken his enthusiasm, but to feed the fire of his genius; not only to afford fit subjects for contemplation, but to give him instruction and advice, and to offer suggestions for his daily labours. Archæology is a necessity with him if he would excel, but its true use is like the study of history—of which, indeed, it is only a branch—to teach lessons of wisdom, of warning, and of hope. But to study ancient art for the purpose of reproducing it, without reference to altered circumstances and times, is the same as studying costume for a fancy ball, or the fables of heathen mythology for the purpose of setting up the worship of Isis or Jupiter. Moreover, it is quite contrary to the spirit of the arts in any age, for no art can be art (paradoxical as this may seem) which subsists on bygone talent, and has no power of its own but that of copyism. Your antiquarian is not generally a surpassing genius of originality, but he lays up stores of valuable lore for those who have the wit or the wisdom to turn them to account.

Now it surely is a matter of surprise, that living in the present, with all the associations and connections of modern life, and feeling all the force of passing events and the attraction of the present time around us, that this spirit of antiquarianism should so often override and overrule our artistic notions, stifling the aspirations of genius, cooling the enthusiasm of youth, and distorting even those inevitable lines of beauty which are traced by the hand of the true artist. Yet that it does so affect the fine arts generally at the present time—and especially our own branch of them—I think few will deny. None can be more ready than myself to admit that its influence is considerably less than it was even a short time ago, and to rejoice in the hope that its cramping and hampering influence shall entirely give way before the genius of nineteenth-century art; that its effect shall be recognized only in the curbing and restraining of too wild and sportive fancies, which, by substituting mere conceits for high art, often in the best periods bring down ridicule and contempt upon art and its professors.

Now let us inquire how, in the history of our own branch of the fine arts, the wants of the period and the capabilities of the times were met,—how far ancient architects were modern in their day.

In Egypt, as far as we know or understand their works, they seem to have had their eyes open to the works of nature around them, in the form of their columns, and the floral and other ornamentation they introduced, and even did not disdain to copy in enduring porphyry the tailors' work of the period. Then look to the use of the noblest materials in the noblest proportions.

Of Assyria we know at least this—that their houses and their temples were suited to their circumstances and their purposes, and that their ornamentation and their sculpture commemorated their modern events.

Who shall say that the great Greeks were antiquarian architects? Slight evidences of Egyptian studies, indeed, are to be found; but how great must have been the *originality* and *inventive* power of their architects,—what infinity of design, what amount of careful thought and study have been gone through before the simplicity of grandeur in their forms and the delicate magnificence of their decoration had been achieved. We hardly appreciate this inventive power in the Greeks sufficiently. Gradual doubtless, but throughout original, and in the end perfect, was the architecture of this wonderful race; but it was also essentially suited to themselves, their worship, and their climate, and the materials around them.

The Romans were a progressive people, and I would give them the full credit of appreciating Grecian works, which is often denied them; while at the same time they were essentially modernists. They had different works to erect, and were masters of more science, though less delicacy of taste, and, let us add, less noble materials than the Hellenes. Far from copying alone, they went on originating and adopting, till at last their originality overcame their antiquarianism, and they produced their grand basilicas, with vaults or domes such as Grecians never dreamt of. Were they not modern? When a circus to hold half the city seated was wanted,—how was the difficulty overcome? Certainly not without reference to precedents, but with unprecedented boldness and success was the problem solved. Who was the Benjamin Edgington of the period who made the velarium? and what were the cushions made of? Such thoughts may help us to realise that these things were not built to be mere picturesque ruins for an English traveller to contemplate on a moonlight night, but were once modern works, to serve the wants of the time.

Then, as to the Early Christians, I am disposed to fancy that a great deal of art we consider modern to them was ancient, inasmuch as they probably adapted many common pagan notions and symbols in their churches, &c. Yet what they built was most essentially different, and had a different purpose to serve from the pagan art around them, and when, as ages rolled on in the darkness or rather twilight of art, church after church was erected east and west, no slavish copy of former types was held, but here a dome, there a round vault, and elsewhere a flat ceiling, all referable to former phases of art, but at the same time all modern in their day, gave a character and a distinctive individuality to the building.

And when at last this darkness rolled away, and the glorious power of the sun of Gothic art was felt, did the art traditions of antiquity or the originality of modern genius stand out as the vital spark of all this blaze? Step by step can we trace the path of this noble development of art, each piece in advance of the other, spurning any backward movement, for three centuries and more. One period, feeling its own power, disclaiming to continue its previous design if it had been stopped in its fulfilment, and taxing its own genius to find a fresh (at that time at least considered an improved) design for the remainder,—artists at one time overstepping the limits assigned by the endurance of their materials, then repairing their error by a fresh and perchance even a bolder experiment, triumphing over material, submitting to every variety of circumstance, and improving every opportunity and every local advantage. Was brick to be obtained and stone not, the baser material was not despised, but shown to be capable of bearing the impress of the artist's mind. Was iron available, it was welcomed by the designer, and wrought out with care, fashioned with the tongs by the smith into forms of beauty. Was glass manufacture established, the painter touched it with his brush, and the architect made way for it in his walls, cutting out of his stone graceful forms of tracery to set the most precious jewels in. Foreign marbles were scarcely wanted where men could find at home alabaster, Purbeck, and serpentine. Antiquity need not be searched for subjects to sculpture when the truths of Christianity were deemed worthy the noblest efforts of the sculptor's chisel. The painters of plaster walls were at no loss how to decorate, whether a flat ceiling or a vaulted roof was to be the subject of their labours. The workers of tapestry or stamped leather, the makers of furniture or armour, were all imbued with the same spirit, keeping up to the knowledge and requirements of their day, and being perhaps as ignorant of, as unable to copy, any art but their own.

And here is the gist of the whole matter: they had not to produce a Grecian work, or a Roman, or a Romanesque, or an early this or a late that, but to do something modern—of their

* Read at the Architectural Association.

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own time and period. Their employers would not have been satisfied with an Egyptian house, a Norman church, a Grecian museum, a Roman exchange, a Romanesque warehouse; but house, church, museum, exchange, or warehouse would have been designed of one date and in the style of the time, embodying the best art which was to be had,—each and all being individual artistic emanations, and no more to be confounded one with another than the individuals who built them.

Living art must be at unity with itself, and when so it must progress. A house divided against itself must fall;—and so is art degraded when its professors are intent on producing archæological specimens, instead of real designs in the art of their own day.

Then as to what is called Renaissance, or Italian revival of the antique;—at the same time that we object to the inordinate reverence for everything of a former period in this phase of architecture, so that art was not valued with reference to its own intrinsic worth, but according as it embodied former notions in every detail, we must admit that the great element of modernism was not wanting in many of its arrangements. Indeed, under the hands of the great surpassing genius of the time it was impossible that it could be. And it seems to me that it is owing to this very circumstance that its influence in our modern times is to be attributed. When men shook off the trammels of precedent, behold what was produced in Florence,—buildings which embody the spirit of their times in every stone. See at Venice what was the effect of Palladio's cold but correct tabular architecture, and read how its proportions are inscribed in all students' books, as if it were a table of some Building Act, showing how the proper thickness of a wall was to be found by the rules of arithmetic. The finest buildings of this period are those least of all correct, and perhaps one of the wildest of all, the church of S. Maria della Salute, in Venice, has in my opinion as fine an outline as any building of any date. Yet, as I said, the necessary element of life existed in the style, viz. its sympathy with the wants of the age and the requirements of the period. I cannot help however stopping to remark the great individuality of the artist, his personal ascendancy over the style; not as in the preceding Gothic period, when the workman was lost in the grandeur of the style, and the great art spirit of the period seemed to pervade all grades alike. I do not desire to lower our estimation of the fifteenth-century artists, but simply to point out this significant fact,—that they seem more prominent than their art.

To come to more recent times, the seventeenth and eighteenth centuries,—how did architecture adapt herself to the wants of that age? Has she generously accepted the altered circumstances of the times,—made the popular requirements her own, and so popularised her art? Has she adopted every new scientific improvement, and clothed it in robes of beauty, adding all the loveliness of grace to mere constructive requirements, and moulding every form of pure workmanship into a shape of artistic excellence? In short, has she been worthy of her high mission? Nay, is it not rather true, that through pride or incapacity she has held aloof from the work of the times,—that of infusing the spirit of her art into everything about her? Despising this, her true mission, she disdained to touch any but great works, and so in turn was not permitted even to direct these, till at last architecture herself seemed dead, and all appreciation of her seemed confined to pure archæological students; and when at last she began to show signs of life, it was in this archæological direction she began to move, and the antique school for a long time endeavoured to keep up this backward tendency.

The architecture which is to endure beyond the fashion of half a century must be the art of the day,—modern in its appliances, its arrangements, and its tastes, like all the great developments of art before it in every age.

In the foregoing remarks on periods of architecture, I spoke of course very generally, otherwise I might have referred to many illustrations of the truth, or to the exceptions which may be found in the works of some individual artist—our own Wren for instance. I might, I think, show where he is essentially modern in his designs for Protestant churches, although he sometimes based his notions on Gothic, partially learned, as well as on Italian architecture, most profoundly studied. I might show that his greatness is exhibited more in his departures from "correct" Classic proportions and arrangements, than in his adherence to them; that his genius is greater where it is least indebted to antiquity; that where he has been most blamed by *dilettanti* architects, he has shown most his high appreciation of the circumstances and necessities of his work;—in fact, that the chief reason of their influence, and the chief value of his works, is that they contain in a great degree that necessary element of all true art—Modernism, or adaptability to the wants, and sympathy with the feelings of the times in which they are wrought. I believe St. Paul's churchyard is the first space which was inclosed by cast-iron railings, and I hardly ever pass by them without recollecting this significant fact. Now, had Wren been properly supported by men of his own profession, had his followers been imbued with his spirit of true art, united to his love of science,—had his mantle of modernism fallen on any of his pupils, or rather had it descended upon any members of his school, instead of being partially caught by a few, what a noble position might our art have been in at this time! What an amount of noble work might have been found in our cities, and what a mass of ignoble and base erections might we have been spared! If he had been allowed to plan London afresh, and been followed by true men, our city might have rivalled any in the world; and we might have taken the lead of all nations in art as we have done in science; instead of labouring day by day,—pushing back a house here and there to get space enough to move along our streets,—beseeching now and then some board of works to grant us a few feet more room to get a sight of what architecture is left to us by that great man! But the real state of the case will serve to show that an individual, however great, has but limited influence; and therefore how vain the hope of any great permanent artistic change, except from a whole generation of artists!

Of course other circumstances had their influence, but I do attribute to the school which Wren founded—to their want of sympathy with their great master's principles—the dearth which followed. It seems to me, that had they perpetuated his principles, and carried onward the work of revival which he in a measure may be said to have recommenced, the public would have learnt to confide in them, and would have entrusted to architects not only their churches, hospitals, and public buildings, but their warehouses, shops, and private dwellings.

Instead of this onward march we have to note a retrograde movement,—less modernism, more antiquarianism; till the building public learnt to believe that architecture was a mere toy, or at best a sort of conventional dress which was proper to be used on state occasions; that it was meant only for display of wealth, or to please the fancies of some learned nobleman. Thus, when a house was to be built, if it were substantial it must be plain—if it were to be good it must must have no gimcrack ornament; till at last your Harley-streets, Baker-streets, and Portland-places were produced, and not only built but, worst of all, considered the right thing. Thus, when a public building was to be erected, the folio of the works of Palladio, or the wonders of Athens measured and drawn by Stuart and Revett, had to be appealed to; or again, the remnants of Rome as delineated by Desgodetz;—and nothing could be done without the sanction of the great god of architecture, Vitruvius. A portico was a necessity; and the originality of a novel intercolumniation of, say an inch or two more than usual—or perhaps an Ionic capital with two baluster sides next each other, so as to show the curls on the outside angle—was the subject of discussion, and sufficient artistic capital for a lifetime. So it came about that an architect must travel to Athens, and pick up sufficient unused "antiques" to form novelty at home;—and the art of design was mere tact in picking out suitable bits to fit in given positions.

To come to even later times, have we not to lament that sort of censorship which has been set up over the early workers of our Gothic revival, by our amateurs and others learned in mediæval archæology! Nay, is this over yet?—must not an architect be prepared with precedent, chapter and verse, for his design, be it from Italy, France, or at home? Has he ever to defend the principles of his designs?—or if he has, and is successful so far—are they admitted without his being able to point to some building or other bearing very near relationship to his work?

If these remarks are considered as applicable to a few years back, but not to the present moment, so much the better. So much are we nearer what this generation, I hope, may yet see,—a rational and national modern nineteenth-century architecture, based on the wants, combining the resources, appealing to the sympathies, and embodying the sentiments, of these glorious days of prosperity and content.

Of style I do not intend to say much, but this I fully believe, that had our seventeenth and eighteenth century architects been all minor Wrens,—looking to his almost at the time *isolated*,

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though perhaps cold, appreciation of some of the beauties of Gothic architecture, noting that more than once he built in that style, with, we may say, partial success;—I say, observing all this, I believe that our own noble examples of Mediæval architecture must have made an impression on the minds of the seventeenth and eighteenth century architects, had they been worthy to tread in Wren's footsteps. We should, I believe, have long ago taken up our national style, and wrought it out into something as superior in power at least, if not in beauty, as our scientific works are superior to, our materials and appliances more varied, than those of Mediæval times. So we should have saved a whole century; and not only this, but, without having progressed, we might at least not have retrograded altogether, nor been compelled to lose further time in picking up lost ideas in experimenting to find the lost path. And again, the nation would not have lost all appreciation of architecture as a modern art, nor looked so coldly and suspiciously on its professors.

We should have had nothing like the National Gallery, purely archæological in all its associations. We should have had a decidedly different British Museum, where all the ideas are referable to Greece; and our churches would have probably contained some allusion in their sculpture or their design to the Christian religion, other than the simple reminder that Paul preached at Athens, from whence also the architectural details were borrowed. Look how Wren rendered the pediment of a Classic building interesting to the people for whom, and illustrative of the object for which, it was erected. Was he right in making St. Paul and his followers usurp the place of Jupiter and his? Then have we been wrong ever since till our Gothic revival. I put forth the broad statement not with reference to pediments only, but to ornamentation generally; and I use it as an illustration of my remarks.

No doubt, the hard study of Gothic has been necessary to ground us in its principles. No doubt, the buildings which have been erected in this style were necessary reproductions of ancient Gothic forms, to give confidence to ourselves and those who employ us; so gaining liberty for our own artistic emanations. No doubt, the spread of archæological study of the Mediæval age among amateurs has led to the formation of a body of the public deeply interested in, and capable of appreciating, the efforts of modern as well as ancient architecture.

But still, it is time we began to build modern churches without always taking ancient churches as our models for every arrangement. It is time we showed the public that Gothic architecture applied to public buildings is not a mere affair of mullions and lead-lights; that a warehouse can be of true modern architecture, and yet accord with the ancient principles of Mediæval, which was, in fact, the greatest common-sense architecture of the time; and that iron girders, and plate-glass, and gas burners, are not inimical to true art, and only a difficulty to a mere archæological architect or church restorer.

An amusing illustration occurs to me:—Some fifteen years ago, a gentleman, looking at the restorations then going on at a church at Bury St. Edmund's (being more of a business man than an artist, and decidedly rather modern in all his notions than antiquarian), spoke to some one in the church who seemed connected with the works, and suggested the introduction of the Bude light, then a favourite patent method of lighting used in St. Pancras, and a few other great London churches, in some of which even now a sort of inverted glass umbrella remains to testify to its adoption. Fancy the horror of the gentleman addressed, who turned out to be the architect, at this bright idea:—"Sir, if I had my way, nothing but wax candles should be used, and few of them."

Yet, though my friend was wrong, we cannot admit that the architect was right, or was working in the spirit of the old Gothic men. The church itself was a mass of window space, which was doubtless filled with gorgeous colour; and yet, a century and a half before, perhaps not more than a hundredth part of the light would have been admitted into the church. Why? Because they had not glass to use.

Shall I be told that Mediæval enterprise would not have used gas in their churches had it been invented, or plate-glass either? And yet we have men, even to-day, lamenting over railways, and gas, and telegraphs, as if the advance of mind in one direction were antagonistic to its progress in another. Rather let us imitate the spirit of Gothic art, by refusing to copy even its sublimest efforts, lest we end by spoiling for ever the effect of the original.

Would our churches be the worse for being warmed and ventilated and used, instead of being shut up and preserved? Rather would it tend to the breaking down of the idea that architecture is a mere abstract idea, and not a living art for daily use and everywhere.

If we are true to ourselves—such is the rising spirit of the art in the public, I believe, such the increase of intelligent, independent judges, such the opportunities of seeing examples of good modern art everywhere, and such the resources at our command—that nineteenth-century art has only to be cultivated, to grow into a flourishing and wide-spread tree. It is already planted: there are those capable of guarding and protecting its tender years; and it only depends upon the rising generation to do their duty, and it will bring forth fruit to perfection.

Let us not forget the magnitude of the work; for it is not only here, but in Australia, in Canada, in India, and Constantinople, as well as on the Continent, our architecture is demanded,—not only ecclesiastical (for some would fain persuade us that our art is only fit for religious purposes), but large secular buildings,—universities, museums, parliament-houses, at home and abroad are rising, and will show in after ages what we were capable of in the nineteenth century.

I question then if there will be much care as to whether the early part of the twelfth century, the middle of the thirteenth, or the late fourteenth, or the too late fifteenth century, was the basis of the design, if only loveliness of form, fitness of purpose, hearty sympathy with the work, and true artistic power be discernible in all.

Then shall we have praise for our modernism, and not blame for our want of it, and though our individuality be lost, what matter, if only the great flow of artistic genius envelope it, instead of its being overwhelmed by the ignominious cloud of incapacity. In a generation of artists, few names, and those of surpassing power, will survive; but if we have all done our work in elevating the art of our day, we may feel satisfied in leaving the result to futurity, and rely on the fair judgment of posterity.

It would take a long time to discuss (but I believe it is intimately connected with my subject) the divorce of science—*par excellence*, the "science" of construction—from the "art" of architecture. It might have been necessary for the onward course of mighty modern inventions, such as railway viaducts and bridges, and so it might inevitably have come to pass even had the followers of Wren been worthy of him. But still, when I recollect what a man of science Wren was himself, when we see what the artistic men of the fifteenth century did,—what the priestly architects of Mediæval times,—what the Roman, or Grecian, or Egyptian architects achieved,—I am constrained to believe that artists must have in a measure *voluntarily* resigned their position, leaving engineers to build bridges, aqueducts, railways, and docks; speculative builders to erect houses, and hotels, and shops, and stores; gardeners and ironfounders to do crystal palaces and railway stations,—and retaining to themselves only the few public buildings which admit of pure æsthetic(!) treatment, and a few private works which their friends may wish to put in their way.

Who built the bridge at Narni 1800 years ago? and who spans rivers and streets, miles in width, in the present day? The architect or the civil engineer? It may be right that our Leonardo da Vincis should confine their attention to canvas or fresco; but surely architects should not have lost all control over the chief civil and domestic buildings of their country. It seems to me that it is in the power of the present generation to regain it in part, and I commend this notion to your consideration.

In the foregoing observations I have confined myself to our own branch of the fine arts, but I believe the same remarks will hold good, in a modified form, with respect to the sister arts of sculpture and painting. Why have we Nymphs at the Bath without end, and so few embodiments of the most stirring incidents of our own history, our own religion, and the events of the present period? Vacant pedestals seem to be our chief advances towards the statuesque decoration of our cities; invitations to young England to achieve something worthy of a hoist up, as if no one yet had done anything for the country but Nelson and Wellington. But there are signs, I hope, of something better in time.

Painting, too, does not disdain to represent the events, the costume, the emotions of the present day, and some of the noblest art is applied to perpetuate scenes which will be hereafter identified with the nineteenth century. But it is as impossible for one branch to flourish without the rest, as for a good tree to

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bring forth evil fruit. Frescoes have begun to enliven our blank walls, and sculpture to adorn our empty niches. Let sculptors and painters look to it—the game is in their own hands.

And now for a few illustrations, and I have done. I have referred to the British Museum as a piece of archæology: now let me speak of the reading-room as a piece of real modernism. Here is the Pantheon dome translated into modern language,—suitable to all its purposes—light, solid, fireproof, convenient for readers; yet wanting somewhat in decorative finish, though this is not the architect's fault. The new Museum at Oxford was in many points not so successful at first; I mean as regards its constructive roofs of iron and glass: what it may be as a work of scientific art we hardly know yet; but of this I am sure, it will be a source of wonder to many who could not conceive the artistic value of metal-work, or who believed our smiths incapable of producing artistic forms in it, and who, when iron was mentioned, had only visions of tubular bridges and wrought-iron girders, studded over with little dots called rivets. Railway engines and tenders have been made highly decorative, and gorgeous metal-work pavilions have been sent after them to the luxurious East.

Our own Crystal Palace does not pretend to be artistic, except in its mighty covering of space; but the Floral Hall is a combination of science and art on a smaller scale, which, as a sign of the times and a great stride onwards, is very valuable. St. James's Hall is another example of the use of modern appliances artistically worked out.

But time would fail me if I were to enumerate the great and small churches, warehouses, mansions, clubs; and, indeed, I must not attempt so great a task as to criticise them even as a whole. This I will leave to your own suggestions, and shall venture to hope that you will be urged to consider some of the points I have brought before you.

ECONOMIC EFFECT DUE TO THE USE OF STEAM EXPANSIVELY.*

(*Continued from page* 116.)

Of the modification of the theoretical result of expansion made by the leakage of the valves.—When we say that the steam is cut off at such or such a point of the stroke of the piston, we mean that the introduction of the steam into the cylinder from the boiler is intended to be suppressed at that point by the mechanism, and would really be so did the valve move steam-tight on its seat. This freedom from leakage however is, from physical causes, and the forms habitually given to the valves, almost an impossibility; and of the large number of indicator diagrams that I have examined, from many engines of various types and proportions, I have never seen one which did not evidence a very considerable leakage. That this should be so is easily understood, when we reflect that the valves employed, with the exception of the poppet and piston-valves, are in general form large flat pieces of metal depending for tightness on the accuracy with which two metallic surfaces, one moving freely on the other, can be made to fit; that the metal of the valves has a different texture and a different coefficient of expansion from the metal which forms the valve-seat; that the valves are faced to their seats *cold*, but when in use have one side exposed to the temperature of the boiler steam, while the opposite side is exposed to only the temperature of the exhaust;—this difference of temperature on opposite sides of a large flat thin piece of metal, acts uncontrollably to warp it and to cause it to leak; the same cause also warps the valve-seat, and increases the leakage, to which must be added what is due to the flutings or channels soon produced by use and corrosion.

In the case of the double poppet-valve, almost universally employed for the American river and marine engines whose rotary velocity will permit it, there is to be overcome the great difficulty of making their two connected discs steam-tight; it is easy to grind one tight, but a very delicate manipulation is required to grind the other tight at the same operation. There is furthermore the leakage due to the difference between the expansion of the connecting stem of the discs, and of the metal of the valve-chest; this could indeed be in a great measure obviated by grinding in the valves hot, but owing to the inconvenience of so doing it is rarely or never done, the valves are habitually ground in cold, and of course leak when hot. The single poppet-valve, which is one flat thin disc, can be ground tight; but it is now scarcely ever employed.

The piston-valve, which depends for its tightness on an elastic packing of the full circular form, is the only kind of slide-valve that can be made and kept tight under the ordinary conditions of practice; the elasticity of the packing permitting it to accommodate itself to changes of form without losing its tightness; but I have known this valve to be used only in a very few cases.

It may be supposed that if the valve and its chest were made of the same metal poured at the same time, both would have the same texture and the same coefficient of expansion; such, however, will not be the practical result; for the two masses being comparatively very small and large, the difference in their rate of cooling will produce a complete change in the quality of the metal. Neither do I overlook the fact that the considerable difference of pressure on the two sides of the valve tends mechanically to keep it flat and in contact with its seat; but this force will be found a feeble antagonist to the force resulting from the unequal expansion of the metal by difference of temperature.

Of the modification of the theoretical effect due to the expansion of steam by the back pressure against the piston.—That the existence of back pressure influences the economy of expanded steam very materially, will be at once comprehended, when we consider that the back pressure is constant, while the steam pressure, counting from zero, is a continuously decreasing one from the point of cutting off; consequently, from that point the back pressure continuously becomes a greater and greater per-centum of the steam pressure as the end of the stroke is approached. Hence results that with the same initial pressure, and the same back pressure, the greater the expansion of the steam the greater will be its loss of useful effect caused by the back pressure; and the greater the back pressure the greater will be the lessening of the theoretical gain due to expansion.

If we suppose the expansion to be carried to such a degree that the steam pressure at any point of the stroke previous to its termination becomes less than the back pressure, then it is plain that the engine is now not only exerting no power, but that some of the power developed by it during the previous portion of the stroke will be abstracted to uselessly overcome the differential of the steam and back pressures. We thus perceive that owing to the existence of back pressure it is possible to carry the expansion of steam so far as to cause its economical effect to be greatly less than if it were used without expansion, a result which would be impossible were there no back pressure. For example, suppose the case of steam of any total pressure, say 30 lb. per square inch, used with an expansion of four times, that is to say, cut off at one-quarter of the stroke of piston from the commencement; suppose also there were no back pressure, and that the steam expanded according to the law of Mariotte, then the mean effective pressure throughout the stroke would be, say 18 lb. per square inch. Without expansion this pressure would of course be 30 lb. per square inch, but there would have been consumed in producing it four times as much boiler steam as when employing expansion; dividing then the 30 by 4 we obtain $7\frac{1}{2}$, which expresses the pressure obtained per unit of steam of fuel using the steam without expansion, while the pressure 18 was obtained from the same fuel using the steam with expansion; hence the gain would be $\left(\frac{18}{7\frac{1}{2}}-1=\right)1{\cdot}4$; that is, the same fuel with the expanded steam would produce 1·4 times additional effect to the effect produced by it without expansion. Now let us suppose a back pressure in each case of 8 lb. per square inch, then the relative mean effective pressures will be (18—8=) 10 with expansion, and (30—8=) 22 without, and as in the latter case four times as much fuel was used, the relative pressures per unit of fuel will be $(\frac{10}{1}=)$ 10 and $(\frac{22}{4}=)\,5\frac{1}{2}$, and the gain by expansion will be only $\left(\frac{10}{5\frac{1}{2}}-1=\right)0{\cdot}8$, instead of the 1·4 when there was no back pressure. If the back pressure be increased to 16 lb. per square inch and the same process repeated, we shall find that the mean effective pressure with the expanded steam will be (18—16=) 2 lb., and with the unexpanded steam (30—16=) 14 lb. The weight of fuel consumed in the two cases being as 1 and 4, we obtain per unit of fuel the pressures $(\frac{2}{1}=)$ 2 and $(\frac{14}{4}=)\,3\frac{1}{2}$; that is to say, the economical effect of the steam used without expan-

* 'Engineering Precedents for Steam Machinery.' By B. F. Isherwood, chief engineer, U.S. Navy. Vol. II. 8vo. New York: Bailliere, 1859.

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sion exceeds that which is obtained from the steam used with expansion in the ratio of 3½ to 2.

The same results would evidently be obtained if, with the same initial steam pressure and the same back pressure, we were to increase the measure used of expansion, that is to say, cut off shorter and shorter; in which case the mean effective pressure with the expanded steam would become less and less per unit of fuel; while with the unexpanded steam it would remain constant; a point would then soon be reached where the gain due to the expansion would be balanced by the back pressure, and if the expansion were carried beyond this it would occasion a loss.

Practically in some engines, as for instance that of the Smithery, with which the experiments were made, the loss from back pressure is equal whether the steam be used with or without expansion, the engine doing the same work in the same time with the same speed of piston. This however is owing entirely to a mal-proportion between the size of the engine and the work to be done, which latter required when working with unexpanded steam a very low pressure, while it permitted with the expanded steam a comparatively high initial pressure, the mean effective pressures in the two cases being identical. The Smithery engine, if it had been worked without expansion and with steam whose cylinder pressure equalled the pressure at the point of cutting off when the steam was used with expansion, could have been greatly reduced in size and still have developed the same power with greater economy of fuel, because the loss by back pressure would then have been much less than when using the steam with expansion. The equality of loss then with equal back pressures, in the cases of using steam with and without expansion, can only be obtained on the supposition of employing too large a cylinder when working without expansion and one of the proper size when working with expansion, the equality not being inherent but accidental, depending entirely on a mal-proportion of size of engine to quantity of work done, and in favour of expanded steam. Hence it is manifest, that as whatever initial cylinder pressure can be carried in one case can be carried in the other, and starting with equality in this respect, there must always be a great decrease of the theoretical gain due to the existence of back pressure. In fact, could the volume of the cylinder of the Smithery engine have been decreased, when using steam without expansion, of the same pressure as at the point of cutting off when using steam with expansion, until it performed the same work with the same speed of piston as when working expansively, the result from expansion would have been reversed, and instead of showing a gain of nearly 17 per centum, would have shown a loss exceeding that ratio: besides which there would be obtained all the practical advantages of a smaller engine—too obvious to be dwelt on.

In estimating the practical effects of expansion, the enormous influence of such large back pressures as we have to deal with even in the case of good condensing engines, have been quite overlooked, as have also been the advantages to be derived from the less capacity of cylinder required for equal developments of power when steam is used without expansion and of the same initial pressure as with expansion.

Still as it may be replied, and with truth, that in many cases, particularly of marine condensing engines, a considerable gain has been realised by using the steam with a greater measure of expansion than before; it becomes incumbent to show that this fact when rightly interpreted is not in contradiction to the foregoing remarks. In these cases it must be remembered that there were employed the same cylinder with the same area of steam-ports, and the same boiler furnishing the same quantity of steam. The gain realised by cutting off shorter was obtained almost entirely from changes accidentally produced in the action and virtual proportions of the mechanism, and not from the fact of any increased measure of expansion *per se*. The sizes of the cylinder and boiler had been in bad proportion to each other, the former being much too large for the latter, as is almost universally the case; and not only was the boiler too small to furnish as much steam of the proper pressure as the cylinder could work off, but it was too small in steam room also. Let us now trace the consequences of this mal-proportion. The first is, that the steam when using the less measure of expansion had necessarily a lower initial pressure in the cylinder, and therefore lost the gain it would have realised from the less proportion of the back pressure had the cylinder been small enough to maintain with equal development of power the same initial pressure as when using the steam with a greater measure of expansion. Again, as with the less measure of expansion a greater bulk of steam had to be discharged in equal time through the same steam-port, the *absolute* back pressure against the piston was increased; consequently, when using the steam with the less measure of expansion, instead of the back pressure being absolutely the same and relatively less, it was both relatively and absolutely greater than when using the steam with the greater measure of expansion. An inspection of indicator diagrams from any condensing engine using steam with different measures of expansion, will show at once how much greater is the back pressure when following far with the steam than when cutting it off shorter. The vacuum in the condenser may be the same, and also the *maximum* vacuum in the cylinder, but the *average* in the latter will be less, and there will be observed a greater and greater rounding of the diagram at the exhaust end as the masses of steam discharged in equal times through the same port become greater and greater, owing to the maximum condensation becoming later and later. Now, as marine condensing engines rarely work with an average pressure exceeding 16 lb. per square inch of piston above the back pressure, and generally with pressures greatly below it, the effect of increasing the back pressure 1 lb. per square inch is equivalent to neutralising more than one-sixteenth of the power, for allowing the friction resistance of the engine to be 1½ lb. per square inch, the net pressure is (16—1½=) 14½ lb., of which 1 lb. is nearly 7 per centum. In engines of ordinary sized ports, I have known the back pressure to increase between 2 and 3 lb. per square inch when the point of cutting off was changed from one-fifth to one-half the stroke, the vacuum in the condenser remaining the same. This increase of back pressure was of course an accidental effect, and would have disappeared on a proper enlargement of the port, but the great economical difference due to it was erroneously attributed to the fact of expansion *per se*.

It may be said with truth that nearly all boilers, and particularly marine ones of the tubular type, have too little steam room; and as a deficiency in this respect seriously impairs the economical effect produced by the fuel, any increase of steam room becomes a source of gain, and every decrease a cause of loss. Now the steam room of a boiler is not an absolute but a relative quantity, and is to be compared with the bulk of steam drawn from the boiler in a given interval of time; hence, if the steam room contain ten charges of steam for the cylinder when the cut-off valve closes at one-fourth the stroke of piston, it will contain only five charges when the valve closes at half stroke; the throttle-valve opening remaining the same in both cases. In this illustration, by simply changing the point of cutting off there has been withdrawn in the same time twice the bulk of steam from the steam room, which is thus virtually reduced one-half. The effect of such reduction is to increase the quantity of water worked over from the boiler to the cylinder, where it increases the back pressure by obstructing the exhaust port, and where it impedes the movement of the piston near the end of the stroke by its want of elasticity and facility of escape. It also lessens the condenser vacuum and increases the load upon the air-pump owing to the large quantity of injection water required to reduce its temperature from that of the boiler to that of the condenser. This additional amount of primed-over water, with its attendant additional amount of injection water, fills the channel way from the condenser to the air-pump, to the exclusion of the air and uncondensed vapour to be extracted: the result is, as has been stated, a lessened vacuum in the condenser and an increased load upon the pump. The water primed over from the boiler carries with it the difference of the feed water and boiler water temperatures, which has thus been uselessly imparted to it at the expense of the fuel if a surface condenser be employed: with a jet condenser there is no loss of fuel in this respect, as a certain amount (about 57 per centum) of the water pumped into the boiler must be withdrawn to prevent the formation of scale, and it is immaterial whether this withdrawal be effected by priming through the cylinder or by blowing-off through the valve provided for that purpose.

The advantageous results of increasing the measure employed of expansion for the steam due to the above causes, would disappear by simply increasing the steam room and enlarging the cylinder steam-ports, and the gain which is now usually ascribed to the fact of expansion *per se*, would then be credited to its proper source. Or, retaining the same absolute amount of steam room and reducing the size of the cylinder, so that when working with the less measure of expansion, and with the same initial pressure as with the greater measure of expansion, the engine developed

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the same power, we would obtain about the same advantageous results in this rapport. I know that in many cases where experiments have been faithfully made with a wide range in the measure of expansion employed, no sensible gain has followed; I am aware also that there have been many particular cases where a marked gain has followed an increase of the measure of expansion: the discrepancy proves the existence of other and modifying causes acting with unequal influence. All errors of opinion in physics have been supported by an appeal to facts, but these are an infallible umpire only when they are rightly interpreted, and the tendency is always to generalise too broadly and to ascribe whatever results follow a change wholly to that change *per se*, without inquiring whether these results be not due to other causes brought into action by the change, and which when removed and the change left to act alone, no longer follow, or with very diminished intensity.

Of the loss of dynamic effect due to the steam used in filling the cylinder clearance and ports.—As it is impossible to place the valve in such contact with the piston at the commencement of its stroke that there shall be no space between them, and as the intervening space is filled with steam from the boiler, and as this steam is exhausted at each stroke of the piston, it becomes necessary to ascertain what dynamical effect, if any, is obtained from it. The problem divides into two cases:—1. When the steam is used without expansion. 2. When it is used expansively.

In the first case it is plain, that as the pressure of the cylinder steam is unchanged during the stroke of the piston, the portion of it comprised in the cylinder clearance and ports, which are filled from the boiler at the commencement and exhausted at the end of the stroke of the piston, acts only as so much filling, produces no dynamical effect, and serves no other purpose than to transmit the boiler pressure to the piston. In this case, then, it is a complete loss, measured in quantity by the contents of the space and the weight of the steam. For instance: let the space displacement of a piston per stroke be 100 cubic feet, and the space comprised in the clearance and steam ports 7 cubic feet, then the loss from this source, if there be no leakage past the valves and piston to the exhaust, will be $\left(\frac{7\times100}{100+7}=\right)6\frac{1}{2}$ per cent. of the quantity entering the cylinder. If there be leakage it will of course diminish this per-centum, for then more steam in equal time will enter the cylinder, while the contents of the clearance and ports will remain the same: for instance, if in the above example there had leaked per stroke of piston 10 cubic feet of steam, then the loss of steam in the clearance and ports instead of being $6\frac{1}{2}$ per centum would have been $\left(\frac{7\times100}{100+7+10}=\right)6$ per centum of the total quantity entering the cylinder.

In the case of using the steam expansively, a portion of that part of it which fills the space in the clearance and ports produces a dynamical effect, because as the expansion of the steam in this space extends to the end of the stroke it increases the pressure upon the piston over what it would have been had no such space existed, but the remainder of the steam filling this space after deducting the portion of it producing an increase of pressure on the piston, is entirely lost; and as this remainder is a higher proportion of the whole quantity of steam used than in the case of no expansion, and the higher the greater the measure employed of expansion—because the space in the clearance and ports is a constant quantity, while the total quantity of steam used decreases in the ratio of the portion of the stroke at which the steam is cut off plus the length of the stroke, to which the space in the clearance and ports is equal—it follows that the loss of economical effect from the steam filling this space is greater when the steam is used expansively than when it is used without expansion, and the more expansively the steam is used the greater will be this loss.

From the preceding description it appears that the theoretical gain due to expansion can only be obtained when the steam is generated and used under purely theoretical conditions; that is to say, when the combustion of the fuel is perfect and the entire heat developed from it is applied to the evaporation of the water, and when the steam so generated suffers no loss either by leakage or condensation, and when its effect is not impaired by friction resistance, by back pressure, or by the space intervening between the expansion valve and piston at the commencement of the stroke. Just however in the proportion that these physical conditions are found to exist, will be the modification practically effected in the theoretical gain due to the use of steam expansively. It will be observed that the obtaining of a higher result in any of the operations intermediate between the combustion of the fuel and the production of the power is a cause of obtaining a higher result from the expansive use of the steam; and that on the degree of evaporative efficiency given by the boiler, on the amount of back pressure against the piston, of the space comprised in the cylinder clearance and port, on the tightness of the valves, on the more or less thorough felting of all the radiating surfaces, and on the general propriety of the proportions of the organs of the machinery and of its dimensions to the power developed, will depend the measure of expansion to be employed for obtaining the highest duty from the steam; and not on any theoretical derivations from the law of Mariotte, which, though rigorously true for the imaginary conditions upon which they are based, are yet subject to such wide modifications by the practical conditions actually encountered with steam machinery, that the predicted advantages may be lessened to any extent, and may even disappear under very unfavourable circumstances, while under the most favourable ones possible there will always remain an enormous discrepancy. We can now understand why in some cases increasing the measure of expansion with which the steam was used notably increased the economical efficiency of the fuel, while in others no sensible gain, and sometimes a loss followed.

Of the effect of "throttling" the steam, or of "wire-drawing" it at the throttle-valve, so as to cause it not only to enter the cylinder considerably below the boiler pressure, but to suffer a continual decrease of pressure during the stroke of piston.—To obtain the full benefit of throttling, the throttle-valve must be placed as near the cylinder port as possible, for the effect of whatever expansion results is spread over the space from the throttle-valve to the piston when at the end of its stroke, and the dynamic effect developed by the expansion in the space between the throttle-valve and the piston when at the commencement of its stroke is entirely lost. In fact, in this respect the same consideration applies to the throttle as to the expansion-valve, namely, that it is essential to its proper action that as little space as possible intervene between it and the piston at the commencement of the stroke. In the case of the Smithery engine, the throttle-valve was so distant from the steam-valve that much of the benefit otherwise derivable from it was lost.

The advantages and disadvantages of throttling, *per se*, may be briefly summed as follows. The advantages are the virtual increase of the steam room in the boiler, and the use of the steam more expansively. The disadvantages are the losses by evaporating steam under higher pressure; by the condensation due to the greater expansion; and by the greater radiation from the boiler and steam-pipes due to the higher pressure of the steam. Whether the advantages are greater than the disadvantages, or *vice versâ*, depends upon conditions which cannot be generalised. In the majority of cases, under the conditions and with the proportions actually existing in the average of practice, there will be found a gain by throttling; the value of the increase of steam room in the boiler and the consequent greater dryness of the steam, as engineers phrase it, or freedom from water in the vesicular state, being more than enough to overbalance all the disadvantages.

In the case of the Smithery engine, referring to the table of comparative results, and taking the mean of the first and second columns, we find that when the engine was worked without the cut-off valve the pressure of the steam at the commencement of the stroke was (16·9 + 14·7 =) 31·6 lb. per square inch above zero, while at the end of the stroke it was only 24·3 lb. per square inch above zero; difference 7·3 lb. per square inch. In comparing the results, however, of the experiments when using the steam with and without expansion, it must be remembered that it was throttled in both cases; the difference in the cylinder between the initial pressure and the pressure at the point of cutting off with the expanded steam being 7 lb. per square inch. The degree of throttling was therefore the same in both cases, and neutralised its effect in a comparison.

On a review of the preceding discussion, there is no difficulty in comprehending how the results from the fuel when cutting off the steam at 22 per centum of the stroke of the piston from the commencement, was only 16·85 per centum more than when using it without expansion. The measure of expansion really employed, it must be remembered (instead of that due to the

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point of cutting off, namely 4·71 times) was owing to leakage only 2·397 times, the theoretical gain due to which is ·874.

In the first place, of the total heat due to the combustion of the fuel only about 60 per centum was used in the generation of the steam, reducing the theoretical gain at once to (·874×·60=) ·5244. Supposing the loss of heat by radiation from the boiler and steam-pipe to have been 10 per centum, this amount will be reduced to (·5244—$\overline{5244\times\cdot10}$=) ·4720; and as of the quantity of heat entering the cylinder with the steam there was lost by the condensation due to the fact of expansion *per se* 33·36 per centum or (·3336×·4720=) 15·75 per centum of the fuel, this amount will be further reduced to (·4720—·1575=) ·3145 of which there was actually realised ·1685, leaving (·3145—·1685=) ·1460 for the losses due to leakage of steam past the cylinder valves and piston without producing dynamical effect upon the piston, and to the space comprised in the cylinder clearances and ports. The effects of throttling, back pressure, and radiation, were sensibly the same in both cases. The space in the clearance and port of the Smithery engine at one end of the cylinder was very small, being only $3\frac{2}{3}$ per centum of the space displacement of the piston per stroke, and as the actual measure of expansion was only 2·397 times, the loss from this source when using the steam expansively was about 4·60 per centum, leaving for the loss by leakage past the valves and piston (14·60—4·60=) 10 per centum.

It is of course not supposed that the *proportions* in the above distribution are *rigorously* correct, for from the nature of things they can only be approximated, but the distribution is right in kind, the final result is right, and the proportions are sufficiently near the truth to clearly show why the experimental result should be as it was, and to practically enable us to discern the direction and limit of improvement.

THE ARCHITECTURE OF THE FUTURE.

At no period has the subject of architecture received a greater amount of attention from the general public than at the present time. Criticism, professional and extra-professional, has familiarized it to most men; and the demands which our social requirements are continually making on its services, gives it a prominence far greater than can be attributed to that general appreciation of art which is still so rapidly increasing among us. This position of pre-eminent success, while justly giving to professional architects occasion for congratulation, is such as to necessitate for its maintenance the most unceasing exertions. Each day not only increases the numbers, but adds to the intelligence of its patrons and critics, who have shown that they can not only form an independent judgment, but that they can produce some of the most judicious and liberal criticisms which have been recently furnished on the subject. It is therefore no mere superficial knowledge that will suffice for the architect of the present day, who sets out with the determination to achieve a position among his professional brethren. The productions of a few years back are looked upon to-day with for the most part much less admiration than at the time of their execution; and the works of to-day will doubtless in their turn be found in this respect to form no exception to their predecessors.

With these signs of prosperity and vitality however, with such unusual opportunities and such incitements to exertion, our architects must beware lest the influence and taste of their patrons should make them become the mere slaves of architectural fashion—if indeed it can be said that for more than half a century we have been in any other than a continual state of transition from one style to another, so rapid as to be fairly open to the suspicion of having been occasioned to a great extent by mere caprice or the charm of novelty. Looking back no further than the time of Nash, we find his peculiar style succeeded by a period when nothing but pure Grecian architecture could be tolerated—when example and rule took the place of combination and design, and porticoes and pediments, applied indiscriminately to all buildings, and in almost all positions, seemed to have been considered the very gems of architectural excellence, as they had become almost the only feature distinguishing a building of importance from the very commonest erection ever perpetrated in bricks and mortar.

That time in its turn was succeeded by the revival of the Gothic and Italian styles, which have furnished sufficient variety to maintain their claim to popular favour till the present time;—and now, when these styles have each been adapted more or less successfully to our wants, the profession and the public seem disposed no longer to let them pursue their undisturbed course, but, breaking into two factions, by lectures, pamphlets, and critiques seem disposed to carry on a struggle, till one style shall reign triumphant and alone.

We are however by no means disposed to say that we could have wished this discussion had never arisen, as we are convinced that more good will come of it than can ever be expected from the mere consideration of abstract principles, while the continual references that are being made to buildings recently erected or otherwise well known, give it an interest to the public generally it could never under other circumstances have possessed. The difficulty which most besets the parties to this difference is that of not losing sight of the interests of art in the mere struggle for pre-eminence, and on that account we should be glad to see a little less of that thorough partizanship which has hitherto been displayed in tolerably equal proportions on both sides. It will certainly, to our thinking, be as wise for each to moderate its hopes of victory, as it will be needless to be dismayed by the apprehension of defeat; for that either style, as a style alone, will ever attain a decided advantage over the other in popular favour is, we hope and think, never likely to occur.

What we wish both our architects and the public to do, is to think more about art itself, and less about the particular form of its expression: let that be thoroughly understood, and a judicious selection of style will be sure to follow; and there will be an end to that narrowness of mind that sees excellence in one style only, and denies the possession of it by any other. It surely can require no great stretch of liberality to suppose that the people who originated both styles had each some perceptions of the beautiful and sublime; yet, were we to take as established facts all the disparaging opinions expressed by each of the contending parties, one would be almost led to suppose that no excellence is to be found in architecture at all. The discussion which has been going on respecting the style of the new Foreign Office forcibly illustrates this. Gothic architects point with pride to the nationality of their style; its Christian origin, in contrast with the Pagan rise of its rival; the truthfulness of its character; its greater suitableness to our climate and wants; its independence of rigid uniformity, and its comparative cheapness. They consider the high-pitched roof to be as especially adapted to our climate as it is peculiarly Gothic, and the mouldings and other modes of decoration in this style are peculiarly suited to our northern sky. The uselessness of Classic porticoes is triumphantly referred to; the cold, dreary aspect of many of our public buildings erected in that style is pointed out, examples of which are for once more enumerated in the Post Office, the National Gallery, British Museum, &c. The Classics, on the other hand, contend that their style has been practised here long enough to make it national, and that if Gothic architecture originated in a Christian age, a Christianity far in advance of that in which it took its rise has sanctioned Classic art by its employment; that the high-pitched roofs of the Gothicists would be all the better structurally were they not so high: while they deny that ill-contrived porticoes are necessary adjuncts of Classic art, and repudiate the idea of taking such buildings as those referred to as exponents of the style. We must ourselves own to a sympathy with the Classics on this last point, for there really is nothing to the purpose in it; though with many of the public, who are content with a superficial view of the question, we can well imagine that Classic architecture has become inseparably associated with the Post Office, Museum, &c. The misfortune for the Classics is that their *style* was the fashion when *art* was almost unknown—had Gothic been the rage at the time it would have fared no better;—and with the many truly noble edifices we have erected in this country in the Classic style, there is no more justice in putting forward such examples than there would be in the man who should turn his back on Westminster Abbey, to point to Westminster Hospital as a specimen of what Gothic architecture can accomplish.

The occasion has in fact been seized by both parties to discover and proclaim the defects and worst examples of the rival style, and the dispute has degenerated into a question about details, instead of being raised and extended into one embracing the general principles of art.

Could each one persuade himself to break through the narrow prejudices with which it is too much the habit of men to trammel themselves—to abandon those foregone conclusions which professional education or early association have suggested, and to

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examine all styles with the eye of a true artist, we think there would soon be a marked improvement in the architecture of the country. Many architects, and amongst them are some whose works to our thinking show talent of the highest order, are equally successful in whatever style they may for the particular occasion adopt;—and it is from an increase of this disposition to practise in more than one style that we think our chances of securing originality and vigour in the art are to be derived. When we have ceased to identify ourselves as partizans, we shall be able with readiness to give up what is useless or inconvenient in any style, and to recognise and apply whatever is beautiful and appropriate,—we shall cease to be servile copyists, and become instead real practitioners in our art. In the specialties of modern requirements and the more extensive adaptation of materials we might find the occasion and the means of giving a decided originality to our works. The church for example has yet to be designed, which shall at once provide a convenient auditory and impress the mind with feelings of solemnity; while we need only name the numerous purposes to which iron can now be applied as one of the many instances of the increased resources our architects possess in the application of materials. Our opportunities in fact seem so extensive and our means so great, while there is such a natural repugnance to mere copyism, that we can hardly wonder at the continued aspiration we find after some new style in architecture. Whether such a style ever will be developed it is impossible to determine, but whether it is or not, it is very certain it will take a much longer time to produce it than those who wish for its advent seem to imagine. In architecture, as in everything else, the influence exercised by new modes of thought or new forms of expression is very gradual, and much time and labour will have to be expended before anything like distinct character can be arrived at.

Our own impression is, that instead of aiming directly to produce a new style, our architects should familiarise themselves more thoroughly with the old styles. Though they might still retain sufficient preference for one as to design their buildings in that alone, we think that a more general acquaintance with the art could not fail to give them greater originality of idea and facility in composition. We have no wish to attempt the consideration as to whether Gothic or Classic architecture is best adapted to our requirements, or whether one style is appropriate to one class of buildings only, and the other to another, or whether either or both might be adapted to all occasions and purposes, as some insist,—at one time awing us by its solemn grandeur, and at another delighting us by its palatial magnificence,—displaying in one edifice the charm of perfect regularity, and in another the varied beauties of the picturesque. It is sufficient for us to know that such attempts at a general adaptation of both styles are being made, and we hope will be persevered in. Gothic architecture will certainly be improved when it has been made independent of irregularities in planning, which are often inconvenient; and Classic art, from treatment in a freer and more picturesque manner than it has generally received. Numerous hints as to the treatment of details derived from the study of one style might be found most useful in the other, and whatever the result of such a course of practice, whether one style would lose its distinctive characteristics in the other, or a harmonious combination would result from the union of both; or whether these would be gradually developed in a style that would be entirely novel in its character, would be of but little consequence to us: it would be sufficient to know that we were working in an earnest and liberal spirit, and were no longer perceptive only, but productive too.

ON LIGHT: ITS INFLUENCE ON THE PROPER ARRANGEMENT IN THE PLANS OF BUILDINGS.

By S. C. Capes.*

The chief beauty of a building consists in the proper adaptation of all its parts for the use and purpose for which it is designed. Plans may be arranged with due regard to proportion and harmony of parts, with all the scientific knowledge of the properties and value of building materials, yet fitness of purpose cannot be obtained unless the subject of light (sunlight) in all its bearings be thoroughly considered, and the quantity as well as quality of light necessary for the purpose intended be provided.

Both the internal and external proportions of all buildings are dependent for their beauty and fitness on this all-powerful medium, light, and its attendant shade; and great has been the influence it has exercised on the buildings and architecture of all nations, as well as upon the minds and habits of their inhabitants. How different is the treatment required for tropical climes to that of our northern countries, and how often have errors been committed by the thoughtless in transplanting the building designs of one country to that of another, the result showing that different degrees of sunlight power can produce from the same edifice an impression of beauty and delight in the one instance, and monotony or gloom in the other. Would the Parthenon create the same influence upon the mind if seen in our own clime surrounded with the London atmosphere, as when viewed in all its simplicity and grandeur at Athens. Or again, would our northern Gothic cathedrals and palaces, with their crisp and playful details, harmonise with the sunny land of Egypt? We might indeed obtain the "dim religious light" effect in the interior for the Gothic cathedral, but would the Gothic exterior be viewed with equal pleasure in the one country as in the other? How many otherwise beautiful buildings have we not seen marred by want of proper attention to this subject, some parts possessing too great a glare, so as to distract attention, and others too much shade, rendering them gloomy, inconvenient, and unhealthy.

Let us proceed with an inquiry into the internal arrangements of the edifices of our own country, and the influence light has upon the general health of man.

In how few buildings do we find all the apartments, halls, corridors, passages, staircases, and other parts properly and efficiently lighted for the purposes intended! It may be easy, and we often have to resort to artificial and borrowed light to overcome an apparent defect; but this is only a poor substitute—in fact, a sham, showing either great laxity of principle or mental application in the art of designing with truth.

We must not suppose that the action of light upon the general health of man is immaterial, for the result of the investigations on the subject has proved that a close and intimate connection exists between it and the performances of the higher functions of the animal and vegetable existence. Plant a seed for instance in a dark cellar, giving it every advantage but that of light: what is the consequence? It takes root and grows doubtless, but the shoots it throws out,—are they vigorous, and possessed of that healthy green colour, the effect of the existence of the healthy juices? No: pale and sickly, the plant droops, growing still, but never arriving at fructifying maturity.

As with vegetable, so with animal life. The natives of the deep dark forests of North America attest this by their unhealthy hue, as much as the blanched plants of the gardener. That the very nature of the gases evolved by plants is altered by the absence of light, is known to almost every one. That small animals are often perceptibly affected by its absence, is also well ascertained. It is known that if tadpoles are nourished with proper food, and exposed to the constantly renewed contact with water (so that their beneficial respiration may be maintained), but are entirely deprived of light, their growth continues, but their metamorphosis into air-breathing animals is arrested, and they remain in the form of large tadpoles.

It is also noticed that persons who live in caves and cellars, or in very dark and narrow streets, are apt to produce deformed children; and that men who work in mines are liable to disease and deformity beyond what the simple closeness of the air would be likely to produce. In many of our large towns are dark cellars, rooms, alleys, and lanes, in which the direct rays of the sun never enter, and which are inhabited by beings who grow up pale and sickly—their young stunted and deformed. As an instance of the value of sunlight, Dupytren, a celebrated continental physician, mentions the case of a French lady, whose disease baffled the skill of the most eminent medical men. This lady resided in a dark room, in which the sun never shone, in one of the narrow streets of Paris. After a careful examination he was led to refer her complaint to the absence of light; and caused her to be removed to a more cheerful situation: the change was attended with the most beneficial results—all her complaints vanished.

It is remarkable that Lavoisier, writing in the last century, should have placed light as an agent of health even before pure air. In fact, where you can obtain abundance of light it is also generally possible to obtain a constant change of fresh air.

If we look to the principles, at present so strongly advocated, for the construction of medical hospitals, we find that they con-

* Paper read at the Architectural Association.

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sist in giving the largest possible amount of external wall space to the wards, whereby both sunlight and fresh air can be admitted with the utmost facilities and to the largest extent. For examples I allude to the so-called "pavilion" plan, with windows facing each other on the opposite side walls, as adopted in the hospital at Bordeaux, the Lariboisière and Beaujon hospitals at Paris, St. John's at Brussels, the new hospital at Malines, and many others. I remember reading, some short time since, evidence in reference to one of our military barracks, in which strong and convincing proof was afforded that the soldiers whose day-rooms and dormitories were exposed solely to the north light, thereby removed from any sun influence, were affected with illness and decline to a very considerable proportion beyond those inhabiting the same barracks but dwelling in rooms having a more southerly aspect.

These several instances have been brought forward, not only to prove that life requires in order to maintain health a plentiful supply of light, but that the light in our dwellings should enter from the south, east, and west sides rather than from the north. Every one knows how dismal and cold a room becomes with a northern aspect, where no sun enters. The shading also of rooms by large trees, suffered to grow too near our houses, is an evil much to be deplored. In our domestic buildings, windows should be arranged according to the purposes of the apartments to which they belong,—whether to be used for morning or evening, winter or summer, with some reference also to the direction of the winds, to encourage the admission of the more healthful breezes, and to exclude as much as possible those of an opposite quality. Let us place the morning or breakfast room towards the east, the drawing-room south, and the dining-room west; to commence with and follow the sun all day. By this arrangement the sun in the autumn and spring months supersedes for a time the necessity for large fires, from the genial warmth it gives to the entire apartments, as well as promoting ventilation, rendering them wholesome and agreeable.

I need scarcely suggest that the cills of all windows should not be more than 2 ft. 9 in. or 3 feet high above the floor level, and that to all dwelling-rooms top lights or skylights should be avoided, if possible. On the northern sides of dwellings should be placed all those rooms for the storage of provisions and other articles requiring to be kept in a cool and equal temperature and free from sun influence; but care must always be taken to provide for a free current of air, so as to prevent the rooms becoming damp and unwholesome. On the upper floors the bath-rooms, water-closets, and store-rooms may have the same aspect, but on no account let the bed-rooms receive light only from the north side. If it be asserted that it is necessary in all dwellings there should be some saloons or sitting-rooms having a cool northern aspect for summer use, or to take refuge in during the hot season of the year, I should say, however tempting such apartments may appear, by all means avoid them; for in all substantial buildings, that is with moderately thick walls, an equal as well as a more beneficial amount of coolness can be obtained by a judicious arrangement of ventilation and blinds. In the former case you will render yourself liable to receive a damp chill, while in the latter you can produce a cool, invigorating, fresh atmosphere.

In the lighting of halls and galleries for the display of paintings and coloured materials, the northern aspect is considered the best, as being the most equal in its light power, and more free from colour: the sunshine, as it is called, having either the colours yellow, blue, or red in predominance, in accordance with the season of the year, and constantly varying in its intensity, would interfere with the due appreciation of the delicate tints in the paintings and materials. In the best arranged galleries for these purposes the light is admitted from the top either through a horizontal or vertical surface, and it is the more essential in a picture-gallery that the window or source of light by which a picture is seen and the picture itself ought not both to come within the range of vision at the same time. Where a light is allowed to pass through a horizontal opening care must be taken to equalise the rays of light by the interception of ground glass or some other medium.

A custom prevails amongst the sellers of Manchester goods and other coloured fabrics, to partially line the south-east and west windows of their sale-rooms with blue paper, so as to produce a neutral grey tint. It must be remembered that light, with very rare exceptions, is compound or heterogeneous, producing two or all of the primary colours. The pure light of the sun produces them in such ratio that, when wholly or proportionally reflected or transmitted, they neutralise each other, and produce white or neutral grey (which is merely a shade of white having no predominant colour), and light producing them in such ratio is often called briefly white or neutral light, the same as we obtain from the northern aspect. In 100 parts of white light there appear to be about 18 parts of yellow, 32 of red, and 50 of blue, all of equal intensity, or nearly as 3 . 5 . 8. When only two of the primary colours occur—yellow and red, yellow and blue, or red and blue—they form secondary colours, orange, green, or purple; and when they occur in the ratio in which they are produced by white light, they form perfect or normal secondaries. Perhaps it may not be too digressive to mention that in ordinary artificial light, such as is produced by gas, &c., the rays producing red and yellow occur nearly in the same ratio in which they occur in the white light; and as there is an excess of them over the rays producing blue, all that is necessary in order to produce white light is to interpose a transparent medium of such depth of blue as to absorb that excess, allowing such a portion of them to pass as is necessary to neutralise the rays producing blue, all of which have been allowed to pass.

It is questionable what effect light passed through coloured glass or other mediums might have on the health of animals; but in reference to plants, botanists sometimes use for glazing their conservatories glass having a slight green shade, under the impression that it tends to arrest the decomposing effect of the red rays, but with what success I have never ascertained.

Many beautiful effects are to be produced in our buildings by the judicious aid of coloured light, not only variegated, as that passing through painted or stained windows of several colours, but also with masses of monotone. I can instance to you the Chapel of the Invalides, at Paris, where, to the best of my recollection, a cool grey light is admitted from the windows in the drum of the dome, whilst over the high altar is thrown a rich sunny tone from the orange-coloured windows at each side; and at the rear is the white light of the large ball. I can also refer you to an instance nearer home, viz., the monument to Princess Charlotte, in St. George's Chapel, Windsor,—the recess in which this monument is placed having on one side a purple-tinted window, casting a cool shade, whilst the other side is lit up with a golden tint, from the yellow glass of a corresponding window, —the effect is quite magical. Many other examples might be produced, but it is more than probable that you are each acquainted with several that have come under your own inspection.

In churches where a large amount of light is not required, coloured glass or painted windows afford means of obtaining a rich glow of warm light, subduing, but without necessarily stinting, the amount of light surface: it may be a question whether the light might not be more equally diffused if admitted from the roof, but for health and cheerfulness the southern should never be omitted. Care should be taken in designing any building for the assembly of many people to listen to and see one or more persons, that the listeners should not be compelled to sit or stand with a strong light facing them, and at the rear of those who ought to engage their attention, otherwise their bodies become weary, and the mind wanders: from the strain upon the eyesight, a sort of soporific influence is produced, in spite of all efforts to the contrary. It is for the avoidance of this that in large halls for lectures, concerts, and in theatres, where strong lights are required, they are carefully removed above the general eye line, or so shaded as not to interfere between the audience and the operators. For examples of churches and large halls lighted from the roof, I could refer you to many which might be studied with considerable advantage:—St Stephen's, Walbrook; Madeleine, at Paris; Pantheon, at Rome; the Reading-room at the British Museum, and many others are familiar to most of you; but I still advocate the introduction of side lights as at St. Stephen's, Walbrook, as an additional means of light and ventilation, and as in the Panopticon, Leicester-square.

We must not overlook one very important duty which we may be called upon to perform,—that is to lay out new districts for building purposes,—nor forget that we not only have to arrange the roads and streets to the best advantage, to obtain the best views, the best drainage, and the largest pecuniary returns to the owners of the soil, but that each house, whether detached or otherwise, shall have ample share of air and sunshine, to avoid placing one side of a street always in shade, and the other monopolising the whole of the sunlight. This duty is too often forgotten, neglected, or avoided, causing an irreparable loss both of

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health to the occupiers, and interest to the owners. With the Building Acts, local and metropolitan, of the present century, it is not at all likely that the same errors as of old will be committed, in allowing of narrow courts and streets to be erected, often without other means of access than small arched openings at either end; and with our improved medical health knowledge we are not at all surprised that these should have become hotbeds of disease and vice. Nor can we ever suppose that the tax upon light and air, called the Window-tax, will again be proposed or submitted to. This tax, born in 1696, is said to have owed its existence to an extensive clipping of the coin of the realm. This general clipping of the coin having necessitated its re-coinage, a great reduction in the revenue followed; the tax was to have existed only seven years, but it expired only in 1851, having been continued for a space of 155 years. Every one has some experience of the injurious effects of this tax, more especially when increased during the great war times. In the houses of the nobility, lights in passages and corridors had been blocked up to avoid excess of taxation. In the houses of the middle classes, staircases, passages, water-closets, attics, and small rooms have been entirely deprived of all external light for the same reason; in fact, it to a great extent prevented the introduction of the best sanitary measures. We can, however, scarcely wonder at the disinclination of the government to repeal it, when we find that for one year, say 1847-8, it produced £1,811,742 upon 485,143 houses.

In making any calculations as to the superficial area of light space required for the necessary proportion of light to any room, due consideration must be given to the medium through which the light passes, as it is well known that a certain proportion of light is absorbed through different kinds of glass or materials usually employed, such as rough plate, fluted, embossed, ground, coloured, and other glass: the light surface area must therefore be increased in proportion to the absorbing properties of the medium used.

The strength of the light in a given space depends upon the intensity of the light, the distance and the angle of the incident light, the size of the window, and the depth of the shaft through which the light must pass: touching the last, other things being equal, that room is better lighted into which the light falls through the shallowest shaft.

Mr. Hesketh, in a paper 'On the Admission of Day-light into Buildings,' read at the Institute in 1852, observes "that in forming any estimate of the light to be derived in any place, variableness in the sources of light must not be taken into consideration, but provision must be made, especially in our climate, for sufficiency under ordinarily unfavourable circumstances. For this reason, a southern aspect must be treated as a northern, and the zenith as the horizon. The hemisphere of the sky will therefore be considered as an equable source of light."

Prof. Cockerell, in his lectures at the Royal Academy, used to state that a skylight yielded four times the light of a window of the same area, but upon what authority I know not. Doubtless, occasionally something should be given in favour of skylights, in consideration of the light falling at angles of incidence more favourable to the reflection and due diffusion of light in the apartment, but, as a rule, the same principles of calculation ought to guide in either instance, as previously mentioned.

In the measurement and proper distribution of light, several rules have been laid down by various authors, but scarcely any of a satisfactory nature. Palladio mentions that it appears to him proper, in conformity to the doctrine of Vitruvius, to divide the height of the side of the room into $3\frac{1}{2}$ parts, and to give to the height of the window two of these parts, and to the width one of these parts, less $\frac{1}{8}$th. In another part he states that the window space should not be wider than $\frac{1}{4}$th the width of the room, nor narrower than $\frac{1}{5}$th, and that the height of each window should be $\frac{1}{6}$th more than double its width; but there does not appear to be any rule or suggestion for the number of windows in the side of a room, or the width of window opening in proportion to length of room.

Mr. James Morris, who in 1734 published his 'Lectures on Architecture,' &c., observes:—"Let the magnitude of a room be given. Multiply the length and breadth of the room together, and that product multiply by the height, and the square root of that sum will be the superficial contents in feet of the light space required."

Gwilt, in his 'Encyclopedia,' allows one foot of glass to 100 cubic feet of room.

In inquiring into the effect of light in a room, it is found that the distance to which light passes into a room after admission, though it makes no difference as to quantity (because exactly as the intensity of the light diminishes, so the area of the surface lighted increases, viz. as the square of the distance from the openings to the part where it falls), yet in practice a room is found much better lighted when the light passes far into a room than when only to a short distance. This effect is caused, perhaps, first by the eyes adapting themselves to particular lights by a slight alteration in their form, and thus, if a room be partially lighted, they adapt themselves to the stronger partial light, and the other parts appear more gloomy: for example, it is well known that, in case of an apartment long as compared with its width, windows of the same collective area at the narrow ends will light it much more effectually, than if the same area of light were admitted at its long side. In illustration let us refer to the ball-room at Windsor Castle, which is 90 feet long, 34 feet wide, and 33 feet high. This room is lighted from the northern narrower side by a window nearly occupying the width, and is supplied by an abundance of light; but, had the same quantity of light been admitted from either of the long sides of the room, so many masses of shadow would have been introduced through the interposition of piers that its effect would have differed most widely from the airy aspect it now bears. This leads me to remark that no pier ought to exist, if possible, in the centre of the side of the room from which the light enters, as nothing wherein more contributes to gloom and dark shadow.

I had wished to have obtained some statistics with reference to the superficial amount of window surface to the cubical contents of some well-known building; but it appears, so far as I can ascertain, that there are scarcely any published statements connected with this subject; and consequently, being unable to make the necessary measurements for myself, I cannot found any new theory for determining the proper amount of light space required for different proportioned rooms, or to judge upon the relative merits of Morris's or Gwilt's rules for the distribution of light. Any information therefore that you can offer will be a valuable addition to a subject upon which very little has been given for our aid. The following may be found interesting:—Pantheon, exclusive of side chapels, proportion of area to light surface, 3399 to 1; British Museum reading-room, 212 to 1; Panopticon, Leicester-square, 385 to 1, (but deduct, say 25 per cent. for coloured glass, 513 to 1); Sheepshanks Gallery, Brompton, 36 to 1.

These buildings show so wide a difference in their proportions of cubical contents to light space, that I have worked out Morris's rule, and have placed the result in the following, side by side with that suggested by Gwilt, and the actual amounts in these buildings:

	Cubic contents. Feet.	Actual light or glass area. Feet.	Required by Morris's rule. Feet.	Required by Gwilt's rule. Feet.
Pantheon	1,899,870	... 572	... 1,374	... 18,898
British Museum reading-room...	1,176,000	... 5200	... 1,084	... 11,760
Panopticon	500,000	... 1300		
Ditto, allowing 25 per cent. less for coloured glass		975	... 707	... 5,000

From which you can draw your own conclusions.

If in this paper I have been unable to inform you of anything with which you were not previously acquainted, I trust that it will tend to fix an impression more firmly on your minds of the necessity of giving due importance in all your designs to the subject of light in all its bearings.

In the *Discussion* which followed the reading of the paper,—

Mr. Lewes said Mr. Capes had treated very properly of the influence of light upon health, yet it was not discovered how that influence arose. He thought Mr. Capes was wrong in questioning the correctness of Mr. Cockerell's idea with respect to the Pantheon, for a very small space in a horizontal position gave much light, and a skylight was more luminous than a light in the side wall. He was also of opinion that in some future Building Act there should be a clause inserted with reference to the height of buildings, in order to insure regularity in the streets, where at present so many buildings overtopped their neighbours.

Mr. Herring thought the discrepancies in the tables given by Morris and Gwilt as to the amount of light required for a

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building, and the amount of space used in the Pantheon, might be accounted for by Prof. Cockerell's rule as to the lighting of the structure by a skylight. It seemed to him that no tabular statement for lighting buildings could be depended upon; they must regulate the lighting according to the aspect, and likewise having regard to the surrounding objects. In a narrow street they wanted three or four times the light space requisite in a wide one. He thought they had merely to examine buildings which existed, and judge from their experience whether they were properly lighted; and if they put the same amount of light in new buildings as was in existing ones where there was enough of light, that would be sufficient, without troubling themselves about any tables on the subject.

Mr. OUGH thought skylights referred more to the country than to houses in the town.

Mr. LEWES said that in the country, in the case of a skylight, they had the advantage of rays coming in every direction, but they could not have that in side lights. A very small skylight would effectually light a lofty staircase.

Mr. CAPES said it must be taken into consideration that a top light was more equally diffused than a side light. After remarking that the ball-room at Windsor Castle was lighted by a large window at one end, he still asserted that there was no more light obtained through a given area at the top of a house than through a given area at the side of a house.

THE FRENCH EXHIBITION.

THE pleasant little gallery in Pall-mall, where this exhibition seems to have found a settled home, is again replete with gems of art of that peculiar class in which our continental friends so much excel. There is the same dull hue pervading the mass of the pictures, and that same delicate touch in giving expression to the details, which mark invariably their productions; while again it appears to us that the peculiar leaning to one kind of subject which more or less influences the majority of artists is in the works of the individuals before us especially manifest. Take for instance the charming groups of Edouard Frere,—so home-telling, so natural, and yet withal mannered. What can be more perfect in its way than "Boys sliding" (104), or the "Lesson on the flageolet" (105), and (106) the "Young drummer taking his lunch"? Then again, Troyon's "Cattle returning to the farm" (231)—the largest picture in the collection—reminds one forcibly of his "Country fair in France," of last year; and Tassaert's 'Sick child" (221), is a kindred subject to his "Last prayer," in the same exhibition. Rosa Bonheur has two small pictures, (26) "Mare and foal," and (27) "Fawns in a cover,"—attractive, of course, as they cannot fail to be, but scarcely so much so as many we have seen from the same hand. Meissonier, a distinguished name, has also but two contributions (170, 171), both very small and highly finished, and to which a very high value is affixed in the price list.

Theodore Frere is, as heretofore, a liberal exhibitor, and all are above the average merit; and Lambinet has no less than eleven pictures, one (145) being an English scene, "Windsor Castle from Horsemore-green." Nor must we omit the two highly-finished productions of C. Baugniet, a familiar name, and one that has done good service to the cause of art. The titles given to these pictures (11, 12) are, "The decision of the flower," and "The toilet." A picture *per se* is (75), Dauzat's "Interior of Coussifa House, Cairo," a very interesting architectural delineation, and carefully made out as to detail. In this the prevalence of a kind of bay window, not unlike some in our own country, will be noticed, also the minaret and dome, which form such pleasing adjuncts to the main subject. It is altogether a capital picture.

"The gladiators," by Gerome (119), is, if we mistake not, one of a pair of pictures (the other being wanting here): it is a noble conception, and grandly treated. C. Muller aspires to an English theme, (177)—"Henry VIII., Thomas More, and Bishop Fisher, at Greenwich;" as does also C. Pecrus (192), "Milton and his daughters." Four little domestic peeps merit attention; they are by Plassan, and are numbered 195—198; and M. Veyrassat displays his skill in several landscapes with horses (249—254). Altogether, a very pleasant and profitable hour may be passed in this snug little lounge of a gallery, by those who are disposed to compare our homely delineations with how they do those things in France.

THE ART TREATMENT OF GRANITIC SURFACES.*

By JOHN BELL.

THE subject on which I am about to make a few remarks this evening is the Sculptural Art Treatment of Granitic Surface, or the Surface of Granite. Although I shall have occasion to speak of the practice of the ancient Egyptians as our masters in this art, yet I shall not do this abstractedly, but with a practical relation to the present day.

Although granite has occasionally been worked in this country locally, it did not come largely into use in our national and large structures until within the last hundred years; old Westminster, and Southwark and London bridges, by the Rennies, being nearly the earliest of those public works in which it was the main material. The style of workmanship adopted in these cases has been in blocks—large, simple, and massive; and whether in connection with large engineering works, other public structures, or pedestals for public statues, this appears to be the proper treatment of it. The Egyptians treated it in the same manner, but with this difference, that they also added to the broad surfaces thus attained a variety of decorated and illustrative incised ornament. This has not been our practice up to the present day, but it appears to me that we might adopt it with advantage: that is, of course, not by copying the Egyptian figures and hieroglyphics, but by only following occasionally that incised method of sculpture, which may surely be held as proper for British granite as for Egyptian; and the illustration of this idea forms the main object of this paper.

Various of the oldest structures in the world are in granite. Some of the simpler features of those in Egypt now existing, nearly perfect, date back between 3000 and 4000 years; and on the other hand, some of the most modern erections in this city, among which I may cite New Westminster-bridge, now in the course of rapid completion, are of granite. Therefore it may be allowed that the value and interest that attaches to this material for architectural purposes spreads over a great extent of human time.

Red and grey form the two great varieties of colour in granite, yet there are also many intermediate gradations, in which nature appears to have arranged her tints to suit all tastes. Most of these are vastly improved by polishing, then also affording examples of completeness combined with endurance of surface, not to be reached by any other material except gems. In thus speaking of this quality of stone, I of course include the syenites, basalts, and porphyries, which are of the same family. Black basalt was used occasionally, both in Egypt and Assyria, for art purposes, as was also porphyry, both stones of great beauty and hardness: also occasionally in modern times. I dare say many of those present have seen the porphyry sarcophagus of Napoleon I., in the noble cenotaph in the chapel of the Hotel des Invalides, in Paris, rising from the centre of the vault in so grand a manner, and which is destined to hold the ashes of the great warrior. The block of porphyry out of which this was formed was of such hardness, that no one person or set of men could be obtained to go through with the execution of it. Nearly every workman in Paris had a touch at it, but necessarily gave it up in weariness. It broke their hearts as well as their tools. Not that each did not do something, for each did, and thus eventually it became completed and polished; and a magnificent sarcophagus it is: but it was too intractable to suit the vivacity of our French neighbours. All this was told me by a young French carver, whom I employed to do some work for me when I was in Paris in 1855, who added that he himself had had three days of it,—which was quite enough.

The hardness of this class of material is one of the considerations that render the vast architectural and sculptural works of ancient Egypt so great a marvel. Although modern research has told us so much about ancient Egypt, and, lit greatly by the lamp of that invaluable Rosetta stone in the British Museum, has so well deciphered the hieroglyphic writing, that an invitation to dinner and a reply might well pass between two *savans* in that character,—although we have found out so much about the history and manners and even domestic customs of ancient Egypt, we do not know how she worked her granite. "Any one," Sir Gardner Wilkinson says, "who has tried to cut a block of Egyptian granite will acknowledge this; and the labour experienced by the French engineers who removed the Obelisk of Luxor from Thebes, in cutting a hole in its pedestal, suffices to show that

* From a paper read before the Society of Arts.

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even with our modern implements we find considerable difficulty in doing what to the Egyptians must have been one of their least arduous tasks." A similar difficulty was experienced by ourselves as to the well-known fragment of Memnon, in the British Museum, more properly Thothmes III. This great bust has, as you may notice, a fracture on the shoulders. In fact the head was first obtained, and the other portion was afterwards sent over to us by the French. To attach this to the other portion it was thought fit to have a hole made to receive a bar to connect them. Our workmen were six weeks in making this hole, and broke a great number of tools in the operation. The use of emery powder, and of the drill and wheel, has been suggested as having aided in cutting the incised work on granite, and any one who has witnessed the rapid manner in which this process cuts our hardest glass, hardly to be scratched even by anything but a diamond, will acknowledge the unexpected power of this process. It has also been conjectured that emery powder was used in sawing Egyptian granite. No doubt it was in polishing it, of which we have many representations. This, however, does not assist us much as to the more general fashioning of the great granite structures of Egypt. One element of workmanship the ancient Egyptians possessed in profusion under their despotic system, namely, that of labour and time. We desire the utmost economy of these now. They had no such ideas. Year after year, no doubt, passed in fashioning an obelisk, and completing its decorations. I have no doubt however, that our steam power, if properly applied, would accomplish within weeks what the Egyptians took years to achieve. In modern days the great columns of St. Isaac's church in St. Petersburg, which are each of one block of granite, 50 feet high and 10 feet across at the base, took a long time in executing;—but time is not valued so highly in Russia as in England. These magnificent shafts are also polished. The shaft of the column of Alexander, in the same city, is in one block: the block out of which it was fashioned was originally 93 feet, the same height as the great obelisk at Karnak, but the proportions of the column having been decided on, they cut off 13 feet, which seems a pity.

In our own country machinery has been applied to turning granite pillars, to working mouldings, and to polishing, but not as yet, I believe, to cutting decorations. Were there however sufficient encouragement for this class of work, we should no doubt soon see the strong arm of steam fashioning granite into art-forms, as readily as assisting our larger operations in planing iron like wood, and rifling steel guns. As it is however, modern times have never as yet reached to the achievements of ancient Egypt, either in the works of granite or the decoration of its surface.

It may always be noticed that each material demands, at the hands of art, a different and special treatment. For instance, wood suggests one treatment, glass another, pottery and porcelain another, metal another,—and even the different kinds of stone suggest different phases of treatment. Among these, granite, from the large compact masses in which it occurs, and its extreme hardness, suggests a broad and massive style of art-use. The delicate work upon Parian or Carrara marble could hardly be achieved in granite, and a Corinthian capital, with all its delicate acanthine undercuttings, would be indeed a long work in granite. The Egyptian had not the marble of Paros, but he had the granite of Syrene, an island in the upper part of the Nile, and various other quarries, as those about Philæ, along its course, which possessed the advantages of direct water-carriage.

The Egyptian, besides his other obligations to the Nile, was also greatly indebted to it for his art, as thus, it was chiefly from the flowers and plants with which it abounded that he drew his more prevalent types of architecture. Of course I do not suggest that all the Egyptian art-forms were floral. The pyramid for instance is not floral, nor the obelisk. The temple also in itself is not a floral form; but no one can regard its façade, and view its more decorative architectural parts, as the capitals of the columns, without perceiving that they are floral forms. The shafts also are bundles of stems bound together, and the bases have the character of roots. The two great types from which most of these and their decorations arose are the papyrus and lotus. On the walls are sketches of these two plants, which I have had made for the occasion, the *Papyrus antiquorum*, or papyrus of Egypt, the full size of the plant, and the *Lotus nymphæa*, or sacred lotus of Egypt, one-half more than the scale of nature. These abounded in the waters of the Nile, and are still found there. You see how graceful they are in themselves, and how well adapted to suggest fine forms for the capitals of columns, and for vases, &c. in which the Egyptians also so much copied them. To illustrate this, in consequence, on the walls you see represented in outline, vastly less however than their real size, some of the celebrated ancient capitals of the Egyptian columns drawn from these types. In those which turn over and outwards at the top you recognise the papyrine type, except where the bud is imitated. In those which are convex and egg-shaped at the sides you perceive the type of the lotus flower. In the first instance the block forming the capital was fashioned into a lotus or papyrine form, and afterwards the various lines of incised ornament were added to complete it, suggesting the petals of a flower or separate flower forms, and occasional leaves and stems, as of the fern and palm, or lotus and papyrus over again. You see how these grand and accepted features of Egyptian granitic art were founded on floral treatment, the types being chiefly the papyrus and lotus of the Nile. Those were beautiful suggestions to the Egyptian. But it is not in Egypt alone that such suggestions are made. Nature—inexhaustible Nature—is rich in such everywhere, and nowhere perhaps more so than in our own meads, moors, woods, and waters. To take a kindred example, what can be more beautiful than what may be called our own lotus, the *Nymphæa alba*,—the queen of the Thames, the white water-lily?

> "The water-lily to the light
> Her chalice rears of silver bright,"—

and her golden sister is a worthy companion. Nothing can be more graceful than those plants, nor more agreeable, I conceive, as subjects for the incised method of decoration used by the Egyptians, but now, as I propose, to be applied and modified to suit our own purposes. As this incised method of sculpture however was peculiar to that people, and they carried it to great perfection, it is natural to refer to them in treating it.

Most of my hearers are probably well aware of the usual treatment of relievo or relief, in sculpture, as in the Greek and Roman relievi in the British Museum, and as usually practised in the present day. This consists of a flat surface or background, from which the sculptured figures project more or less. This has been the practice of this class of art among most nations, but it was not the practice of the Egyptians. Their figures in relievo did not project, but were rather impressed, being tucked in, as it were, round the edges, into the surface, the highest part of the figures being only level with the surrounding plain face into which they were cut. And this is called incised relievo, in contradistinction to projecting relievo.

Now doubtless this mode was recommended in a degree to the Egyptians by its convenience as well as by the simplicity of its workmanship. For instance, the faces of an obelisk, or tomb, or temple, might be hewn down quite plain, without any previous arrangement of projections left for the sculpture, the very subject of which might be left for after consideration, as was evidently occasionally the case in Egyptian works. The ease and convenience that thus in this respect attached to the method then, would of course equally attach to it now. Take for instance the large granite forms of a bridge. These might be hewn with the greatest breadth and simplicity, and yet afterwards, either before or after erection, the blocks which composed it might receive the decorative enhancement of incised relievos.

One remarkable art quality also must not be overlooked in this incised method of relievo, viz., that while it decorates a surface it does not disturb its breadth, enough of the true original surface always remaining to assert that. Nor does it take away from the impression of solidity, but rather the contrary. Also, it does not injure the profile. You may recognise at once how the effect of an obelisk, for instance, would be destroyed by any projecting relievi on its faces; how in that case its grace and character would be lost at once; while, on the other hand, any degree of incised enrichment is applicable to its faces, without any disturbance of the original contour. This would suggest that this mode is applicable also to columns of elegant proportions.

Another advantage of this style of work is its enduring character, especially when worked in granite. There is nothing to knock off. In fact, it excels in endurance the other styles of relievo as much as the material excels other stones, as is illustrated by the endurance of various Egyptian works of ancient time, in which some of this incised relievo has stood exposed to the atmosphere for more than 3000 years, without being materially injured.

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I am however, of course, only suggesting the use of this kind of relievo occasionally, in addition to that which is the general practice, and this only in reference to certain features of architecture wherein an unbroken general line of contour is desirable. Also as regards material, in reference to granite, metal, and such hard stones as would retain the sharp lines of the bounding incision. I conceive however that on a large scale it is suitable to granite surface specially, and this probably also more for the introduction of emblems and floral decoration than for any elaborate treatment of the human figure. For instance, I conceive it might occasionally be well introduced on the granite pedestals of our public statues, as calculated to give them interest, and as relieving the surface without disturbing their simplicity. In consequence, I am myself using it cautiously, and in small degree, on the sides of the granite pedestal of the Guards' Memorial, in Waterloo-place. On each of the two sides of this, in incised ornament, are being worked, besides the names Alma, Inkermann, Sebastopol, a pair of bayonets crossed, a wreath, and three stars, according to the outline you see on the walls, which is a working drawing, full size. Of course this is but a small instalment of this method, but I hope it will meet with favour.

The whole gist of what I would suggest amounts to this, that whereas we have now for the last hundred years begun to use our native granite largely in public structures, yet we have not (except in some isolated instances, in which the Egyptian architectural style and details have been followed in the decorations themselves—which is not what I suggest—as well as the method of incising) applied this facile method nationally; that is, using the method, but applying it to forms and decorations of our own time and country. I conceive that it might be well if we did, and that in that case it would open up a fine fresh field for design.

Before we go into this subject, perhaps it would be interesting to us just to glance over our own chief localities of native granite. The Scotch granite of Aberdeen and its neighbourhood is much and justly celebrated; that from the quarries of Darncing-Cairn-Rubislaw and Tyrebagger is grey; around Peterhead the red granite chiefly prevails, of a fine deep colour; and in the neighbourhood is some of a tint between the two, of a fine appearance. The West of Scotland also yields fine granite. Ireland also yields granite of various qualities from Wicklow, Down, Newry, &c. Leicestershire yields the brownish red kind, the Mount Sorel, which is very hard, and has come into use much of late for paving. The Channel Islands, as Guernsey and Jersey, also yield granite of good quality.

Of the southern part of our isles, no portions are in this respect more celebrated than Devon and Cornwall. On the extended plains of Dartmoor, in the former county, lie on the surface, or only partially embedded, boulders of granite sufficiently large apparently to furnish blocks as large as those used in Egypt. Cornwall however is on the whole a most prolific county for granite. The granites of this county used in the new Westminster-bridge are from the quarries of Lamorna, Penryn, &c. The quarries of Cheesewring, also in the same county, have furnished granite largely for the new bridge, and it gives much satisfaction. This granite is of a fine even texture, of which the crystals, while sufficiently large to show well as granite, are yet not so large as to interfere with the appearance of work put on it, and it is therefore well suited for the incised decoration of which I have been speaking. From its delicate grey tint also, when polished especially, it forms a most pleasant combination with gold, as in letters and devices cut into the surface, and gilt.

The modes of working the granite in all the British quarries are, I believe, much alike. Holes are drilled or jumped, as it is called, into the rock: these are supplied with gunpowder and fired, and thus the great masses are blasted out, which are afterwards split into blocks with gear consisting of steel wedges, and "feathers," as they are called. This block, in which you see these inserted, is partially split, the crack being started. They are afterwards fashioned with a large hammer, called a muckle, and pitching tool, and various picks, points, and chisels, such as you see on the table. If a fine surface is required it is axed.

When holes are to be made, they are frequently, as I have said, jumped. The tool with which this is done consists of a long bar, thick in the centre to hold by, with a chisel edge at either end. It is used thus: by being raised and let fall with a jumping motion, whence its name; and, being turned partially after each blow, thus wins its way through the hardest block. Polishing when required is now done greatly by steam. This process must enhance the appearance of most granite, but is from the hardness of the material necessarily costly. In a general way the cost of polishing may be set down as an addition of one-half the previous price. Thus, if a column costs £20 fine axed, it will cost £30 or something more polished.

I would now come to the art-treatment in our own days, now —of incised decoration on this most enduring of nature's materials, one also that is so widely spread in this country, and which is justly coming every day more into use. In saying this, however, I must premise that I have but the result of a very short and limited experience to put before you, and therefore no doubt many shortcomings may be perceived, and I hope excused. In truth, the chief objects in connection with which I have considered the subject have been mostly confined to tombs, pedestals, obelisks, and drinking-fountains.

Last year I read in this room a paper, which among other matters treated rather largely of the obelisk, as a monumental feature of art suited to the present time, especially with the addition of some delicate scientific modifications of its lines and surfaces, in some respects analogous to the entases of Greek architecture. The society thought so well of this, that they honoured me with a medal for it. In studying thus the obelisk, I naturally thought of the incised decoration of its surfaces analogous to the hieroglyphics which were wrought on these features of art by the Egyptians. Inscriptions in our own character of letters, carefully adjusted and arranged, would effect this. Also a treatment by means of emblems, especially floral and foliage ones, as the rose, shamrock, and thistle for the British Isles, the lilies for France, &c., supposing a symbolizing of different nations was desired. Also, for a public drinking-fountain the obelisk might have appropriately incised on it the flowers and ferns of our island that delight in pure water. Thus, by this means the surface of the obelisk would tell an appropriate tale, and the decorations have their symbolic and apposite meaning, as the hieroglyphics had on the obelisks of Egypt, which caused Strabo to call them "open books," only in a fresh manner.

With reference to the use of granite for drinking-fountains, and the adoption of incised floral ornament, the author said, it is a fact which affords a pleasant proof of the influence of the agreeable in art over the mind, that people will stop and drink at an agreeable-looking drinking-fountain, who would not think of refreshing themselves at a pump with an iron ladle. Observation has fully tested this. Especially, therefore, does the making these features of public utility pleasing, as well as enduring, appear an appropriate subject of art. If they are to be made enduring, we may allow that no materials are better than granite and hard marble. Also as they are, especially during the summer months, in much use, that kind of decoration which is least likely to be injured by the touch is that which may be thought frequently appropriate. And the incised decoration which we have been considering has this advantage, that there is nothing to knock off, it being protected by being sunk. It also leaves the outer surface so as to be easily polished.

I am not saying by any means that these are the sole materials suitable for drinking-fountains. On the contrary, there are cases and situations where metal or other materials are preferable, and perhaps essential. Nor am I saying that incised ornament is the only kind of decoration suitable for such purposes. Quite the contrary: I only suggest it as one of the suitable methods. In whatever way however these objects of utility and social benefit are designed, it is important that they be designed suitably in each case in reference to their site, and so as to enhance and never to detract from the surrounding features already existing, especially as, for public utility, they naturally occupy prominent situations.

In accordance also with the impression, that in all cases when possible decoration should tell some true tale;—and in this respect, in the way of art suggestion, it is pleasant to know that our Flora is quite as graceful as that of any other country; old England being quite as fruitful in such suitable natural types as old Egypt;—there are our beautiful ferns, with their feather-like fronds, easily traced on the granite or marble, so many of which delight in the margins of pure water. There is the Phyllitis, or hart's-tongue fern, either the plain or the fingered, which loves to hang from rocks which distil fair water; "Les rochers qui pleurent," as the French have it,—the rocks which weep.

Then there is our well-loved forget-me-not, the *Myosotus palustrus*, which delights in the sides of brooks. This however

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cannot be said of the iris, fleur de luce, or wild flag, which loves the shade of willows.

Of all the British plants however, of which the names, even as casually repeated, transport us in imagination to charming country haunts, none are so inviting perhaps for the present purpose as the beautiful white and yellow water-lilies of our waters—the *Nymphæa alba*, or white nymph, and the *Nymphæa lutea*, the yellow or golden lily:—

Oh, Thames of many waters!
See on thy placid breast reclines
The fairest of thy petalled daughters,
That pure white nymph that buds and binds,
In raft-like forms, her flowers and leaves
In flakes upon her glassy bed;
And with her gold hair'd sister weaves
A chaplet for thy head.

Nowhere, indeed, shall we find these two sisters of the floral kingdom in more beauty and perfection than in many of the windings of the upper part of the Thames, as near Maidenhead, Cookham, Great Marlow, Henley, or Pangbourn, where in the months of June, July, and August, they may be seen flourishing side by side in great perfection. Every point about these two plants is beautiful; the long graceful stems, the cool green leaves, either aspiring up from the clear blue depths, pointed like a spiral shell, or spread out broadly over the surface of the water. It is needless to speak of their buds and blossoms, they are so known and admired; beautiful as each plant is, they afford at the same time so charming a contrast as to be especially fitted for combination in ornament. Even the seed vessels and fruit are of beautiful ornamental forms. Altogether, Old Gerard, who lived in Holborn, in his 'Herbal,' or Great Old Book on Flowers and Plants, published more than 250 years ago, calls them, *par excellence*, "the roses of the waters." Moreover, he adds, "if taken with meat they do invite purity and temperance," so that in this respect, as a moral and æsthetic symbol also, they are *d'accord* with the objects of public drinking-fountains.

Did we, in the kingdom of the lilies, wish to go further a-field, among the beautiful varieties of their class which nature affords us, we shall find perhaps none more beautiful, nor certainly any one so magnificent, as *Euryale amazonica*, or Victoria Regia, of the river Amazon.

I have in the models and marbles before you availed myself to some degree, inadequately as yet, of some of the elements of form suggested by these lilies. The standard drinking-fountain, of which there is a model in the centre of the room, takes its type of decoration from our own white and yellow water-lilies, as also the vase by my side. In the marble mural one on the table, the Victoria Regia lends the art-suggestion in the bud, blossom, and leaf—in this case however, smaller than nature—for its decoration, jets, and basin. This is not specially a granitic design, yet it is of a character easily effected in that material;—indeed, I have no intention of confining my suggestions of such treatment solely to incised decoration, although that mode now naturally presents many advantages in its application to large masses of hard stone. Also, when flowers are used as the types of decoration, I have no idea of suggesting water plants only. Egypt was simply the great valley of a mighty river, and many circumstances which I have alluded to made the Egyptians look to that river for almost everything. But in the British Isles we are in quite a different position, with our extensive seaboard, and variety of scenery and climate,—greater, I believe, than any that occurs in any other portion of the world's surface—and of consequent variety of flowers and plants: among these are types appropriate to very many subjects. For drinking-fountains water-lilies may be appropriate; but these and other features of art may well also, I conceive, receive the enhancement of many other floral suggestions which nature offers for our acceptance.

As regards, however, the whole question of floral decoration, I trust I shall not be misunderstood. No one would take exception more than myself to direct "natural ornament," as it is called, forming the staple of art-decoration at all times. On the contrary, I only conceive it may occasionally be used with effect, and that the incised method we have been considering to-night affords one agreeable opportunity for the introduction of it in certain cases on the surface of granite and other hard stones.

You will recognise that in the above remarks I have avoided somewhat the consideration of architectural structure, confining myself more within my own specialty to such examples of smaller features of art as I had in some degree considered. I did this intentionally, leaving the larger field to others.

In the *Discussion* which followed—

Mr. Robert Hunt, F.R.S., said, on the occasion of the discussion on Mr. Burnell's paper upon Building Stones, recently read before the society,* the question arose as to the permanence of granite, and reference was made in the paper to London-bridge and Waterloo-bridge, as affording specimens of granite decay. He was quite willing to accept the reference to those structures as specimens of granitic durability during the time—although it was comparatively a short one—that they had stood. A question arose as to the causes which led to the disintegration of granite, and they were told that, in the case of Waterloo-bridge, they would see the felspar crystals decomposing, and leaving holes in the stone. Now, this was not the fact, and any one walking over old Westminster-bridge would find projections known as horse-teeth, consisting of felspar crystals, standing high up. The other constituents of granite had decayed, and the felspar remained intact. He stated on that occasion that he did not believe in the decomposition of felspar having produced, for example, the china clay, which was referred to as an instance of the results of the decomposition of granite. He might state generally his views upon it—views not hastily arrived at, but after many years examination of all the granite masses of England. He found that there were granites, as he believed, of very different ages, certainly of very different characters. On Dartmoor, and at many other places where they were working granite for building purposes, they found a very hard and durable material, containing little or no evidences of being metalliferous; but if they took a band of three miles in width, extending from Okehampton in the north to Plympton in the south, they could find a granite which was richly stanniferous; and the whole of that granite they would find in a friable state, and unfit for building purposes. Another formation resting on this appeared to be the china stone or china clay, and similar formations were to be found in Cornwall, especially at Penryn and St. Austell. Mr. Bell had stated his opinion that granite was an igneous rock. He (Mr. Hunt) did not think it was so in a strict sense. It was not like the greenstone or basalt. It was not a mass poured out in a molten state from below; but seeing that the granitic masses contained particles of water, his impression was that the granite was formed from the solution of its constituents in water at a high temperature; and these softer granites and decomposed portions were not really granites which had been decomposed, but granites which, so to speak, had never been properly formed by nature; and he believed if they took the granite which nature had finished making, they had one of the most durable stones that could possibly be obtained. Mr. Bell had referred to the incised ornamentation of granite. Any one who was familiar with Cornwall was aware of the large number of ancient crosses existing there. They were of three distinct periods. Some of them he believed to be as old as the introduction of Christianity into Britain; others he imagined to be about the time of King John; but taking the most ancient of them, they found a considerable amount of incised ornamentation, similar to that which was presented by the Egyptian works, which was as perfect at the present time as the day after it was chiselled. The beating of Atlantic storms upon these crosses had produced little or no impression. He found two or three cases in which the driving of the sand had had an effect upon them, although the weather appeared to have exercised no influence whatever. There was one point on which he would venture to suggest that Mr. Bell was somewhat in error. Referring to the quarries from which the beautiful Cheesewring granite was obtained, Mr. Bell had told them that there was a work of art in the neighbourhood from which the stone derived its name. That was an error. The Cheesewring was unquestionably the work of nature. There had been enormous masses of softer granite disintegrated from the harder portions during the lapse of time, and the masses which remained in a solid form constituted the Cheesewring. With regard to the duration of granite and the ornamental work upon it, he might refer to the remains of the churches which still existed upon Dartmoor. Those churches were built during the reign of King John, when that monarch granted peculiar privileges to the "tinners," as they were called. At that period there was evidently a large population upon Dartmoor, and many churches stood where houses were now scarcely to be found. Those churches were ornamented in a very elaborate manner, and though now covered with moss, the work was quite perfect at the present time. It appeared, therefore, as regarded the duration of granite, that it was a material particularly suitable for the recording of noble deeds which were worthy of being immortalised. Mr. Bell had dwelt at some length upon the numerous varieties of granite. It should be remarked that singularly white and beautiful variety alluded to existed, not in the ordinary form, but as a huge granite vein running into the other mass of granite, and thousands of tons of it might readily be obtained. They had upon Dartmoor many varieties of grey granite, and, in small portions, some beautiful specimens of red granite. In Cornwall is found the bright granite of the Cheesewring, which ranked amongst the most durable of all; and from its peculiar structure, and from there being no very great difference between the sizes of the respective crystals of felspar, quartz and mica, it appeared to be a quality of stone well suited to the purposes of the artist. In Leicestershire they found some varieties of granite, and a great deal of stone was brought from that county into London which was called

* See *ante*, page 101.

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granite, but which he thought would be more correctly termed syenite and greenstone. Another very beautiful granite was the Shapfell, a specimen of which was to be seen in the hall of the Museum of Practical Geology. The durability of that stone had been shown, up to the present time, not so much by works of art; but at Redcar, on the eastern shore of Yorkshire, they would find boulders of this granite which had been brought there by icebergs in ancient geological times, and lodged upon that shore, where they had remained till the present day. And here was shown the disintegration—not of the felspar—but of the other constituents of granite, in the same way as in the case of old Westminster-bridge. He considered granite the most durable of British stones, valuable not only for building, but also for ornamental and decorative purposes.

Sir JOHN RENNIE, F.R.S., said there could be no question that, practically speaking, granite was the most durable stone they could employ. He had himself seen in the quarries of Egypt, to which reference had been made by Mr. Bell, specimens of the granite which had been used for the obelisks of the Egyptians, and on which the ornamentation was such as Mr. Bell had described. They would observe at Alexandria, in the case of Cleopatra's Needle, that the only means by which the granite had been disintegrated was from the action of the sand driven by the simoom winds, the attrition of which had worn away the edges. He was struck with the power of the wind to carry the sand when, in coming from Egypt, some 40 years ago, he was surprised to find the capstan and the rigging of the vessel in which he was sailing, covered with fine sand. He inquired of the captain of the vessel how far they were from the nearest land, and was informed about 130 miles. To show what might be done with granite, he would mention that it was used by Smeaton for the Eddystone Lighthouse. At that period it was called Moor-stone, and it was so hard that they could not get workmen to look at it. It was got from the moors in large blocks, but the working it was considered impracticable. It was however used for the Eddystone Lighthouse without any dressing, in combination with mortar. When the construction of Waterloo-bridge was contemplated, in 1809, his late father proposed that it should be of granite; but he had great difficulty in getting masons to work upon it. The consequence was, the granite of that bridge was procured at a cost of 7*s.* 1*d.* per cubic foot, which he need not say was an enormous price. The balustrades, which were of Aberdeen granite, cost £3 15*s.* each. They could hardly realise the idea of such prices in the present day. Shortly after that he was engaged, under his father, in the erection of Southwark-bridge, for the foundations of which it was necessary to get large blocks of granite, weighing from 15 to 18 tons each. That was thought impossible. However, they were obtained, and were brought from Peterhead to London, and were worked at 20 per cent. less cost than had been the case with Waterloo-bridge. Then followed the present London-bridge, the upper portions of which were decided to be of Aberdeen granite. Owing to the experience that had been gained in the other instances he had alluded to, the stone for that bridge cost only about 5*s.* 3*d.* per cubic foot, being a reduction of 30 per cent. upon the former cost of the material, merely as the result of experience. In Mr. Burnell's paper upon building stones, it was stated that decomposition of granite might be observed in London-bridge and Waterloo-bridge. He certainly was not aware of anything of the kind. There might be some discoloration from the oxide of iron, but as to disintegration or decomposition of the granite in those structures, he had never seen it. When they came to polishing red granite the cost was enormous. He had paid £25 for a small slab forming a sideboard, which at the present time could be had for £10. In Portugal the whole of the northern district of the country was a mass of granite. The Portuguese were a very industrious people, and the churches of Oporto, formed of granite, were very elaborately ornamented, and in them he had not been able to detect the smallest disintegration of the material. From his own observation and experience, he was satisfied that the more granite was introduced into this country for building purposes, the more economical the buildings would ultimately be, inasmuch as it was impossible to calculate the duration of that material. He might particularly instance the granite column at Ramsgate, which had been exposed to the influence of the south-west winds and storms for about 30 years, and they could not see the least effect upon it.

Prof. TENNANT referred to Mr. Burnell's paper on Building Stones, recently read before the society. On that occasion, in the course of some observations which he made, he stated that the cost of transporting materials from Windsor to London, in former times, before the introduction of railways, was £3. 10*s.* per ton. Since then he had referred to the authority from whence he obtained his information, and he wished to correct that statement;—he ought to have said 30*s.* per ton, and by water 9*s.* per ton. The present charge by railway was 2*s.* 8*d.* per ton. With regard to granite there was much misconception. If they referred to any good geological work they found that granite was composed of three simple materials, quartz, mica, and felspar, and it was to the preponderance of one or other of these substances that the characteristics of the different varieties were due. There were also several kinds of felspar. Sometimes the colouring of the granite could be traced to the felspar; and the white granites were partially composed of albite; and the syenite consisted of quartz, felspar, and hornblende—the latter taking the place of the mica of the true granite. The Mount Sorel stone was of this character, and was extensively worked for road material; and another beautiful example of the same kind was afforded in the Malvern granite. Then they had basalt, which was used by the Egyptians to a great extent, fine examples of which were to be seen in the British Museum. The Rosetta stone was an example of this. There were also two obelisks of that material there, upon which there were several thousand characters engraved, and these were amongst the finest monuments of antiquity in that magnificent collection. There was one beautiful illustration of the syenite in this country, but little known; that was an obelisk at Kingstone-hall, near Wimborne, in Dorsetshire, brought over by the late Mr. Bankes, in 1819. He had seen a description of it; there were three Greek inscriptions on the pedestal. Syenite was composed of felspar, quartz, and hornblende, with occasionally very minute scales of mica. The decomposition of that material was in his opinion greatly due to the mica; the water could get in between the plates and disintegrate the mass: the quartz itself would last for ever. If they wanted a thoroughly compact material, not capable of being acted upon by any of those influences, they must take porphyry, which was of uniform texture. The porphyry of Scotland, he considered, was equal to that of Egypt—equal also to the celebrated Swedish porphyry—and to some which was found in Bohemia. Then there were the conglomerates, a sarcophagus of which material was exhibited in the British Museum: in a work published by Charles Knight there was a drawing and description of that sarcophagus, in which it was stated that the characters engraved upon it amounted to no less than 21,700. This conglomerate was composed of brecciated jasper, which would last for ages, exceeding the durability even of granite.

Mr. ROBERT RAWLINSON said, in the early part of his life he was engaged on the works of the Liverpool Docks, where more granite was used perhaps than in any other place. He thought granite had not been used in this country to the extent it ought to be, and might be used. One insuperable barrier to that was the cost. The cost of granite at the quarry, as compared with freestone, was as 3 to 1; in some cases it was as 5 to 1; and the cost of working those granites in the plainest manner would be in about the same proportion. It was well known that freestones and limestones disintegrated very rapidly in this country. This deterioration took place generally in the dripstones, which were most exposed to the action of the water. It appeared to him that if a material upon which water had no action, such as granite, were introduced at these points, it would preserve the other material of the building intact, and would also give a beautiful variety and relief, by introducing a little of the Byzantine character. It had been correctly stated, that to work granite in any, even the plainest manner, was very expensive, and when anything like raised ornament or moulding was introduced, the cost became enormous. He could mention the instance of the door-case of the police-station at St. George's-dock, at Liverpool, which cost £95. Granites were very largely used in the Liverpool docks—not as ashlar, but as rubble. The sea and dock walls were many of them built of small stones. They had begun in the first instance by quarrying enormous blocks of from eight to fifteen tons each, until vast quantities of *debris* were accumulated in the quarry, which induced them to supersede the use of ashlar, and to construct the walls with granite rubble, which he thought would prove as durable as the granite itself. The prices varied from 2*s.* 6*d.* to 4*s.* and 5*s.* per cubic foot for the rough stone delivered at Liverpool from Dumfriesshire. The prices depended upon whether the stone had been scabbled or not: it was frequently sent unscabbled, and for scabbling they paid 1*s.* per superficial foot.

Sir JOHN RENNIE was surprised to hear such a price. He had had the finest Penryn granite delivered at Ramsgate at 2*s.* 3*d.* per cubic foot.

Mr. C. H. SMITH called attention to a large granite tomb which was erected in the burial-ground of St. John's, Westminster, to the memory of the master mason of King George I. He believed the date of that tomb was about 1722, and he thought it was the oldest specimen of ornamental granite in London. It showed no signs of decay.

Professor MORRIS remarked that the numerous objects of Egyptian antiquity in granite which had been handed down, were probably the largest and most enduring monuments that ever existed. The Romans also largely used granite. Subsequently, during the period called the dark ages the material was very little used, until its application was restored in Italy about 1379, by an Italian artist of the name of Peruzzi, who established a manufactory for the working of hard stones. A similar manufactory was established in 1472 by an Italian named Ferucci, who worked largely upon these hard stones. Granite was also much used in Florence, and 116 years after an establishment was erected by Ferdinand, Grand Duke of Tuscany, which remained up to the present time, and in which the numerous works in granite and porphyry from Florence had been and were still produced. With regard to the general use of granite, he could add his testimony to that of Mr. Bell as to the extreme desirability of extending the employment of that material, more especially when they found that all that had been done of late bore no comparison with the extent to which granite had been used in past ages, In a report by the commissioners of the Paris Exhibition, it was stated that the Louvre contained more monuments of antiquity in granite and porphyry than had been executed in Europe since the period of the Renais-

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sance. With regard to what had fallen from Mr. Hunt as to the probable origin of the granite formations, they all knew the fact that granite was not an irruptive rock. Whether molten or not, it had never been poured out upon the surface of the earth; but there was evidence to prove that felspar, quartz, and mica belonged to that class of minerals which did not contain water, but were considered to have their origin from the crystallization of mineral matter in a state of igneous fusion at great depths, assis ed perhaps by the action of water in a state of steam. These two forces combined, acting for a lengthened period while the mass was gradually cooling, had engendered that peculiar crystalline form which characterised granite. Another point which Mr. Hunt would admit was,—that they found granite in the form of veins, not only the newer granite pervading the older, but frequently intruding into the adjacent strata. There were two kinds of granite in ordinary use; and a more careful study of their composition might enable us more accurately to compare their relative durability. The granites mentioned as having been used by Mr. Macdonald were of two kinds,—the red and the grey, but he believed both consisted not only of felspar, mica, and quartz, but of two kinds of felspar, one of which was the ordinary felspar of granite, the other a felspar containing a certain amount of soda, or a felspar of the sixth system. One other point was as to the working of granite; to which the attention of Mr. Bell had probably been especially directed. He was not aware whether that gentleman had visited the celebrated works of MM. Bigot-Dumaine and Hermann, of Paris, who were probably two of the largest workers of granite in that city. He had been informed that they worked and polished their granite by the use of a species of black diamond obtained from Brazil, fixed in wood or brass. In Sweden, at Akershuus, a prison near Christiania, prisoners were employed in polishing granite, and it was stated that the manner in which the work was done left nothing to be desired. Another point was the peculiar decomposition of granite itself. Mr. Bell had probably noticed the colossal arm of Thothmes III. in the British Museum, which was called Egyptian syenite. There was a peculiarity whi.h bore upon the working of that granite, as it did upon all other kinds, which was this—that it appeared to decompose or exfoliate in layers, presenting a rough cleavage structure, parallel to the planes of the worked surface, but at right angles to the force employed in working it. In that arm the granite did not break off in the direction of the crystals, but broke off parallel with the circular form of the arm itself, the direction of the exfoliation having no relation to the crystalline structure of the felspar or quartz, but he believed there was a law still to be worked out as to the occurrence of this exfoliation. The columns of Peterborough cathedral, constructed of Barnack rag, were an example of it.

Mr. RAWLINSON attributed the exfoliation in the manner described by Prof. Morris, to the jarring effect of the blow upon the stone in working it. This had the effect of disintegrating to a depth below the surface.

Sir JOHN RENNIE mentioned that granite had been used for the construction of a large dry dock at Sheerness; and the cast-iron gates, weighing 59 tons each, were fitted into the granite so closely that the connections were perfectly water-tight.

Sir T. PHILLIPS said, that in the consideration of the art-treatment of granite, especially with regard to incised decoration, their attention was naturally directed to that remarkable people the ancient Egyptians, who had left a more lasting impress upon the face of the globe than any other people. They had produced works whose antiquity it seemed scarcely possible to determine, exhibiting qualities of conception, invention and treatment which he ventured to say would be remarkable in any age, and were eminently remarkable in the age in which they were produced. They had erected structures the vastness of which could only be conceived fitly by those who had seen them. As to their actual beauty many might differ, but as to the great skill with which they had been executed he thought there could not be much doubt; though such works could hardly be appreciated now, owing to our ignorance in many cases of the circumstances which they were intended to commemorate, or the purpose for which they were designed. It had been his good fortune to look upon some of these works in Egypt itself, and he would especially refer to that gigantic work on the western side of the Nile, in the valley known as the "Gates of the Kings." They there found themselves in the midst of stupendous excavations made 3000 years ago; and the mode in which that ravine had been excavated and tunnelled into corridors of great length, and chambers of great extent, was such as to astonish every beholder. They found the whole of these surfaces, extensive as they were, covered with the incised decorations to which Mr. Bell had called their attention. Standing in one of these chambers, they saw the first step was to produce a polished surface equal to marble; then that surface was covered with the drawings intended to be represented; after the drawings had been made the incised surface was produced, and the objects were presented with a truth, precision, and peculiar grace (although the latter was not generally regarded as a characteristic of Egyptian decoration), which could hardly be excelled at the present day. He had stood in one of the chambers which was left incomplete in its decorations, part of the walls being covered with drawings of remarkable beauty. All this went to indicate the extraordinary care and wondrous labour, and great expenditure of time, which characterised the works of this ancient people. With regard to the incised sculpture, he thought it must be admitted that it contributed largely to architectural effect.

The following communication upon the subject of the paper was received:—

Sir GARDNER WILKINSON says,—The admirable remarks of Mr. John Bell have presented many convincing arguments in favour of the employment of granite; and a judicious treatment of the material itself, with a proper introduction of ornament adapted to that massive stone, and in accordance with our wants, our tastes, and our climate, is capable of introducing a new era into the use of granite for monumental and ornamental purposes. This in the hands of Mr. Bell promises to be carried out with success. But in the treatment of it we ought to be satisfied with no mere copy. We require it to be original and English; and no imitation of Egyptian work will satisfy or accord with English requirements or taste. We may derive hints from those who, like the Egyptians, have had great experience in its use, but we should hesitate to adopt Egyptian ideas, either in the form of granitic monuments or in our mode of ornamenting them. I can fully appreciate the merits of Egyptian architecture, but I can see its faults; and though I admire the vastness of conception, the knowledge of constructiveness, the skill they showed in sculpturing as well as in transporting granite, I must allow that the Egyptians were deficient in real taste; and while it is the exception to find any object of Greek workmanship deficient in grace and beauty, it is the exception in Egypt to find it possess those high recommendations. There is little that we can adopt from the Egyptians, either as tasteful in itself, or adapted to the style of our monuments. The curve of the cornice, which is broad in its character, the simple shaft of one of the old Egyptian columns, with its graceful shallow grooves (the prototype of the Greek Doric), and a few devices—as the papyrus, the lotus, and some others—are of a pure and elegant form, but the general character of Egyptian architecture is remarkable rather for solidity than beauty; and though the Egyptians deserve credit for being the first to lay down the principle of variety in the juxtaposition of columns with different capitals, and in avoiding the monotony of repetition of form and ornament throughout a building, we can neither imitate their columns, the style of their buildings, nor the character of their sculpture. Mr. Bell recommends the adoption of flowers as ornaments, to be sculptured in "incised relief" (or, as I have termed it, "relieved intaglio") in granite; but it is a question how far floral ornaments, such as ferns and similar delicate plants, are suited to a material which requires the ornamentation to have the broadest kind of treatment; and I agree with him when he says that the flowers should be treated conventionally, and not present an appearance at variance with that character of ornamentation required by the nature of the material. The Egyptians did not fail to perceive this; and the granite pillars of Karnak are ornamented by water plants in high relief, of the boldest and broadest character. For though the Egyptians sculptured granite in intaglio, and in relieved intaglio, they sometimes cut figures of men and plants, and even hieroglyphics, in relief, on the same kind of stone; and one temple, at Behayt, in the Delta, presents hieroglyphics in high relief upon all its granite walls, as well as on the columns, architraves, and other parts of the building. I have also seen the human figure sculptured in relief on granite to the height of nine inches above the surface; and Egyptian figures in relief may be seen in some museums of Europe.

Remarkable instances of floral, heraldic, and various fancy devices, as well as human figures, cut in relief upon granite, are met with in various parts of Cornwall; and the church of Launceston, built in 1524, is covered with them, transferred from an unfinished house in the neighbourhood, which was to have been decorated with these sculptures; which however, I must confess, are heavy and graceless, and little worthy of imitation.

Mr. Bell mentions the extent of the quarries in Egypt; and very justly calls attention to the quantity of granite suited for monumental and ornamental purposes which we possess in the British Isles; and such is the extent of the quarries in Dartmoor and in other places, both in England, Scotland, and Ireland, that the remark made by Pliny respecting the porphyry quarries of Egypt might well be applied to them—"quantislibet molibus cædendis sufficiunt lapidicinæ."

With regard to the erection of obelisks in England, I confess I am altogether opposed to their adoption for monumental purposes, as I have elsewhere had occasion to state. We attach no meaning to them; we have no association connected with them; we do not even appear to understand the use for which they were invented; and we employ them in places and positions diametrically opposed to their character and to the principle which led to their adoption by the Egyptians. They served as a vertical line to contrast with the long horizontal character of the Egyptian temple, where their effect and position were admirable. We place one by itself in some open space like a monster gnomon; and, what is worse, we even design a chimney in imitation of an obelisk. We also spoil the character of the obelisk by mounting it on a Roman pedestal, which entirely interferes with its general form and character, and we depress its apex as if we wished to deprive it of an important feature which constitutes one of its peculiar beauties.

The mere imitation of an ancient monument, in no way suited to our wants, tastes, or predilections, is a sad sign of deficiency of inventive talent; and unless an obelisk is so placed as to accord with the purpose for which it was originally devised, it is a false application of an ill-

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understood principle. The right application of it will, I have no doubt, be duly considered and determined by a sculptor of Mr. Bell's great proficiency and taste, and we shall no longer have to condemn obelisks as unmeaning objects, and as the refuge of those who are destitute of invention and the ability to design an original monument.

It is by the adaptation of an older or a foreign principle that many of the fine monuments of Greece and other countries have been devised. It is no disgrace to borrow an idea from another style. It is only the mere slavish copy which is a proof of the want of genius; and the whole history of architecture proves how one style has grown out of another, by adoption and adaptation, according to the wants and requirements of each people. This adaptation seems to be one of the great principles which Mr. Bell takes as his guide; and his intention of introducing a suitable art treatment into our modern monuments—as public fountains and other structures—will confer a benefit on public taste.

THE SOLIDIFICATION OF LIMES AND CEMENTS.*

By George Robertson, C.E., F.R.S.E.

In collecting data for a paper on the "Blue Lias Mortar" used in the late extension of the London Docks,† published in the Transactions of the Institution of Civil Engineers for 1857-58, I was much struck with the confused views both of engineers and chemists on the subject of limes generally:—the one, from want of sufficient knowledge of the chemistry of lime; and the other, from a deficient practical acquaintance with it on the large scale. The subject is one of interest in a scientific point of view, as considerable vagueness still adheres to the theories connected with it. Its importance to the practical man is undoubted; for the reputation of an engineer depends, or at least ought to depend, on the permanent success of his works.

The following observations are deduced, not only from the investigation above alluded to, but also from more recent experiments, principally upon the richer limes in the neighbourhood of Edinburgh, and upon cements, both natural and artificial. I have endeavoured to eliminate as much as possible whatever is useful only in a professional point of view, as unsuited to this place; at the risk however of greatly diminishing the interest attached to the subject.

The experiments made on the London Dock works related to the calcination, slaking, and grinding of lias lime; to the composition and setting of different mortars, both in air and water; to the expansion of limes in the act of hydration; and to their contraction while setting. The effect of the various methods of treating limes, upon their adhesive and cohesive properties, was carefully examined, and much useful information derived from this part of the investigation; for it is evident, that no method of treating lime which injures the adhesion, either between its own particles or between them and external objects, can be approved of; as the chief use of mortar is to cement materials together.

The experiments (which I found very difficult to conduct so as to give *fair* averages) lasted two years, and extended over many thousand tons of blue lias, and smaller quantities of "greystone" lime and cements; the manufactured value of which as mortar and concrete, for this one work, was upwards of twenty thousand pounds. The subject is therefore evidently one of economic value, as well as of scientific and professional interest.

Besides the specimens set both in air and water, six pairs of bricks were always joined together with the same mortar or cement; and, after being kept for from one week to twelve months, according to the nature of the experiment, were torn asunder by weights suspended in a large scale capable of holding two tons, attached to the bricks by iron nippers with broad serrated claws. Columns of brickwork were also made and crushed in a powerful hydraulic press; or were broken as beams, resting on two supports at a given distance apart. The latter class of experiments were found to be very uncertain in their results, which at best were only comparative.

The solidification of lime may be conveniently considered under two heads, each capable of two separate sub-divisions. I use the word solidification in preference to the ordinary term "setting," as comprising the whole process of hardening, first by setting, aided afterwards by hydration, evaporation, action of silicic acid, or absorption of carbonic acid; some or all of which, as the case may be, are useful in the final induration of limes and cements.

The first great class, which we may call A, comprises those limes and cements which *do not set permanently hard under water*, which *may* set hard for a time, but eventually soften, from the solvent action of the water. This may be subdivided into a_1—where the lime is used *slaked*, in the form of hydrate; and b_1—where *quick* lime, or the cements from the sulphate of lime, are used.

The second great division, B, includes all limes and cements which *do* set *permanently* hard when immersed, and which increase in hardness even under water. This is also divisible into two classes of a somewhat similar nature,—a_2, the solidification of *slaked* hydraulic lime; and b_2, that of *quick* hydraulic lime and cements.

In the first class, A, which includes the rich and fat, as well as the poor and sandy limes, the action of setting is chiefly from mechanical causes. In the second class, B, the main cause of permanent hardness is chemical.

I make these two divisions, because it appears to me that no lime or cement ought to be called "hydraulic" when its safety in water depends only on mere mechanical protection from solubility. However successful such protection may be at first, it assuredly leads to ultimate failure; and in truth it is the cause of a great deal of the confused and contradictory statements which exist in connection with limes. A more or less chemical protection from the solvent action of water, I hold therefore to be essential to all limes in class B, that of hydraulic limes and cements.

First, then, the solidification of limes which do not set permanently hard under water. a_1 The simpler subdivision of this class, is where the lime is used slaked with water, as a hydrate, after having had its carbonic acid driven off in the kiln: the object of calcination being to gain those adhesive properties which belong to the hydrate, and not to the carbonate of lime. The addition of water and sand, to form mortar, with the simple hydrate of lime, cannot have any chemical effect; because water, which was used in slaking, has already had its full chemical effect in forming hydrate; and sand is the insoluble form of silica, which has been proved to have no chemical effect whatever on lime. The action of setting in a_1 cannot therefore arise from chemical, but must be from mechanical causes.

Does the mortar set by reason of the evaporation, or of the absorption of the water of mixture? It was found that a cubic foot of mortar, which (besides a large quantity of water rendered latent in forming hydrate of lime) contained 17 lb. of absolutely free water used in guaging up the materials—set hard before it had lost half a pound by evaporation. It hardened to the very centre, with the loss of only one pound of water. Evaporation was here evidently not even essential to the setting of the mortar, much less the cause of it, as is very commonly asserted in works on the subject.

The sixteen pounds of water, which have neither been taken up chemically nor lost by evaporation, have in part been mechanically absorbed by the pores of the lime, and in part retained by capillary attraction between the grains of sand. This absorption of the water changes the mortar from a fluid to a solid state, leaving the grains of sand connected by an adhesive network of hydrate of lime. In short, the mortar "sets," and the set is accompanied by a contraction in bulk (caused by the absorption of the water) amounting to one fortieth in the case above mentioned, but often more; which further increases the solidity and density of the mass.

A large portion of the 16 lb. of free water can be squeezed out of the mortar by an hydraulic press; and even with the ordinary pressure of a trowel, enough can be forced out to convert mortar, apparently solid, again into a soft and almost liquid state. The water of hydration can only be got rid of by heat.

In the subdivision b_1 of the first class, the lime is used for mortar in a different form,—as the anhydrous oxide of calcium, quick lime. When guaged up in this state, although as before the sand causes no chemical change in the condition of the lime, the water of mixture now acts with heat, and forms hydrate; with considerable expansion, not contraction, of the bulk of the mortar. If only the same quantity of water be used as in a_1, this expansion not only "blows up" the masonry, but also leaves the mortar friable, porous, dry, and void of adhesive properties. In practice therefore an excess of water has to be used with quick lime: first, to furnish enough for the hydration of the lime, and secondly, to leave a sufficient quantity to keep the mortar in a fluid state till the injurious expansion attending that hydration is over. When the lime has become a perfect hydrate, then the

* Paper read at the Royal Society of Edinburgh.

† See *C. E. & A. Journal*, vol. xxi. (1858) p. 200.

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surplus water of mixture is taken up, as in a_1 by capillary attraction, and the mortar sets without fear of friability.

In the use of ordinary quick lime therefore, though the set may be hastened by the chemical action of slaking, it is still really caused by mechanical absorption.

In the cements from gypsum, in like manner, the sulphate of lime, which was rendered anhydrous in the kiln, on being guaged up for use, first regains its water of hydration; and then absorbs its surplus water of mixture, and solidifies with contraction.

In the first division of the subject we have now mortar, hard set in the open air; either entirely from mechanical causes, or aided by the chemical act of hydration. In course of time the solidification increases, from the gradual evaporation of the free water of mixture lying dormant in the pores of the lime. This free water tends to cause a softening of the lime in its immediate vicinity. Or, where evaporation is impossible, the solidification may still increase, from the withdrawal of this water by the porous nature of the materials joined together by the mortar. A certain amount of softening is at first necessary to cause cohesion in the particles of the mortar, and to enable it to enter the interstices of the surfaces to be cemented, and there harden *in situ*. But the softening should then be arrested by the withdrawal of some of the free water, by evaporation or otherwise, else there will be some danger of the mortar returning to a pulpy state. This has occasionally happened to mortar, to the no small astonishment of those using it.

The last stage in the solidification of ordinary mortar is the induration caused by the absorption of carbonic acid from the atmosphere. In course of time this changes the surface into imperfect limestone, which protects the mortar from the weather, and is the sole cause of the hardness of very old mortars in this country, where pozzuolana has not been used.

When the materials joined together are limestones, I found that the mortar absorbs carbonic acid likewise from the stones themselves, somewhat in proportion to the richness of the stone in carbonate of lime. It was also ascertained that the *pureness* of the lime in the mortar (and especially its freedom from silica in chemical combination with it) is favourable to the gradual penetration of carbonic acid through a mass of brickwork. The depth therefore to which carbonic acid is absorbed into mortar in a given time, and to a certain extent the induration from that cause, varies inversely with the hydraulic properties of the lime, which depend upon the silica contained in it.

The second principal division of the subject (B), comprises all limes and cements which set *permanently hard under water*. Subdivided into, a_2, where *slaked* hydraulic lime is used, and b_2, comprising the case of quick hydraulic limes and cements.

When sand and water are mixed up with slaked lime, in the subdivision a_2, there is, as in the class A, a quantity of latent water in the hydrate of lime, capable of being expelled by heat; and also a quantity of free water, capable of being squeezed out of the mortar by mere pressure. The porous particles of lime, acting as before like a sponge, draw up this latter quantity and absorb it, with a contraction in the bulk of the mortar. But as the whole mass is now supposed to be immersed in water, the *permanent* set cannot result from *dryness*, arising either from absorption or future evaporation. The sponge is moreover soluble when composed of pure unprotected lime, and could not therefore harden of itself from mechanical causes.

In limes which set permanently hard under water, there must be some chemical change in the particles of lime, which renders them practically insoluble, and, as it were, petrifies the sponge, which cannot harden from desiccation. In hydraulic mortar the particles of sand are therefore embedded in an insoluble and gradually hardening matrix of lime in combination with some protecting agent. The mortar not only sets, but resists the softening action of the water.

The solidification cannot now go on increasing from evaporation, as in the case of mortar set in the open air; but gradually hardens, at first from the completion of the protecting petrifaction, and afterwards from the absorption of carbonic acid from the water in which it is immersed. The induration from this latter cause is not so speedy, and probably not so great as in rich limes, because there is less carbonic acid in water than in air, and because hydraulic limes exhibit a greater indifference to it; the effect before-mentioned of silica, the petrifying agent in combination with the lime.

The substances usually found in hydraulic limes, which each in turn have had the credit of protecting them from solubility, are manganese, iron, magnesia, alumina, and silica. It is now admitted that the chief credit belongs to the silica, which, by the formation of a silicate with the lime, enables it to set permanently hard under water. Silica is found in water limes under two forms: in the anhydrous and useless form of sand, which has no effect on lime; and as a hydrate, more or less in combination with alumina.

If clay (or silicate of alumina) be heated in a flask with lime water, it will be found in time that the water shows no alkaline action upon reddened test-paper, proving that the lime has entered into combination with some of the silicic acid of the clay. The same happens, though not so freely, when pure gelatinous silica is heated with lime water; even when the silica has been moderately dried to a mealy powder. It would appear that in clay the silica is presented in a more favourable form than when used pure. In practice, double silicates (of lime and alumina) are found to form harder mortars than silicate of lime alone.

This experiment of heating clay in lime water somewhat coincides with the first part of the manufacture of that eminently hydraulic substance, Portland cement, in which clay and chalk are calcined together, after having been intimately mixed in a fluid state by a pug-mill. The water is however soon driven off in the kiln, carrying carbonic acid with it, and the combination between the lime and silica, which would otherwise take place, arrested, by the anhydrous condition of the lime, unless the heat be pushed to extremes, so as to cause absolute fusion of the silica and lime. It will be seen hereafter that the combination to any extent of the lime and silica *in the kiln* is very undesirable.

Hydrated alumina heated with lime water takes up a little of the lime, but has practically so little effect in setting lime under water, that I cannot call it more than an indirect agent, of use in hydraulic limes only as a carrier of silica in a useful form.

The oxides of manganese and iron have no effect when heated with lime water. The iron in pozzuolana may even be withdrawn by an acid, without destroying the power of the earth in setting rich lime under water.

Magnesia and lime are found in somewhat intimate union in dolomite; but my experiments with magnesia failed in assigning to it any other value in limes than that of giving them a certain amount of mechanical protection from softening, by its own greater insolubility, while it greatly injures their powers of carrying sand.

Silica being therefore the protecting agent which enables hydraulic lime to set permanently hard when immersed, it becomes important to examine into the nature of its action, and the time at which the action begins to take place, in order that, in practice, full advantage may be taken of its hydraulic properties, without if possible injuring the lime in other respects.

If rich quick lime and clay be mixed together, even in the most intimate manner in the dry state, and then guaged up as mortar, no observable hydraulic effect will be produced by the clay. But if the rich lime be mixed with clay, after the clay has been properly calcined (either artificially, or like pozzuolana, in Nature's kiln), then the silica of the clay is now found capable of acting on the lime, and of rendering it insoluble. The silicic acid will act still more energetically if the clay and lime be calcined *together*, after natural mixture, as in lias lime and in Roman cement, or after artificial mixture as in Portland cement. It appears necessary for the action of the silica that the clay be first rendered anhydrous, or nearly so; and to be an advantage if the lime be rendered anhydrous along with it.

When calcined together, as in hydraulic lime and cements, the question arises, whether the silica and lime combine in the kiln or afterwards? That they can be forced to combine by fusion we know, but that renders the lime as perfectly useless for mortar as powdered glass would be. The hydraulic action of pozzuolana when mixed with rich lime, proves that union in the kiln is at least not necessary; but is the more perfect action in lias and cement due, as is commonly supposed, to combination during calcination? My experiments lead me to think it is *not*, and that the silica and lime do not unite to any extent till the lime has been slaked and become a hydrate, and then only when surplus water is present. The total quantity of silica in hydraulic lime or cement may be ascertained readily enough, but it is not so easy to determine the exact time at which the silica begins to leave the alumina of the clay to combine with the new base lime.

What led me at first to think that the silica remained in combination with the alumina through the process of calcination, and

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only combined with the lime when hydration was complete, was my noticing the adhesive properties of lias mortar at different stages of setting, and after different modes of slaking.

I have already said, that while lime is a carbonate it has little or no adhesion. Powdered chalk, or powdered lias limestone, would make a very poor mortar indeed; but drive off the carbonic acid in the kiln, and both the rich lime and the hydraulic lias become capable of uniting materials when guaged up with water and made hydrates. In the case of the chalk where there is no silica, this can only take place from the circumstance that hydrate of lime is adhesive, while carbonate is not. So long as air be not admitted, to furnish carbonic acid for the reformation of the carbonate, chalk lime will retain its adhesive properties for an indefinite time.

If lias quick lime be slaked with exactly the quantity of water necessary to form a hydrate with the amount of oxide of calcium contained in it, then the lias may, like the chalk, be kept for long without losing its adhesion when mixed as mortar. But, if the least extra water be used in slaking, then the lias begins to get friable and worthless. Chalk lime may even be mixed up with water into a paste, and allowed to set hard; and then, if powdered and remixed with sand, it will still make good mortar. But, once let lias lime or the hydraulic cements be guaged up with water, and no readmixture will ever make a mortar worth anything.

It appears to me, that these differences in the behaviour of chalk and lias can only result from the formation of silicate in the latter, after the hydration is complete: that in fact the hydrate of lime is adhesive, the silicate of lime is not.

It is reasonable therefore to assume, that up to the point of calcination at which lias retains its full adhesive properties when mixed afterwards as mortar, no union has yet taken place between the silica and the lime: that the lime is still in its rich, pure, and unprotected state, and able to exert its full powers of cementation. If the heat go beyond this point, and cause the formation of silicate by fusion, then the lime is spoilt, as effectually as if the particles had been coated over by a silicate, formed more gradually by the friendly action of an excess of the water used in slaking. The closer the proximity of the anhydrous particles of lime and clay in the kiln, the more perfect will be the hydraulic action of the silica afterwards; as in Portland cement, where the materials are pugged together in a liquid state before calcination.

This point in the theory of hydraulic limes is one not merely of scientific interest, but of great practical importance to the engineer who desires to make the best possible use of given materials. To gain the greatest amount of adhesion with the smallest proportion of lime, the mortar (according to the above theory) must be in the work *before*, and not after, the formation of the silicate of lime. The proper method of treating lias in order to obtain this desirable result is explained fully in my paper on Lias Mortar, already referred to, and is too much a subject of professional detail to be suited for the Royal Society. I may mention however, that mortar can be made at pleasure of 10 lb. of adhesion to the square inch or of 30 lb., with the same proportion of lime and sand, by a very slight difference indeed in the treatment of the lime. Surely then the subject is one of importance, to the practical man, as well as to the theorist.

Recent experiments made at Leith Docks with Portland cement have given me more direct proof of the probable truth of this theory,—that the silica combines with the lime after hydration is complete, and not—at least not to any extent—in the kiln. I chose this cement for examination because it is calcined at a great heat; the lime and clay being likewise in intimate mixture, with moisture, in the kiln. The probability of the silica and lime being in combination after calcination and before hydration, would therefore be greater in the case of Portland cement than in the naturally hydraulic limes, which have a less proportion of silica in their composition and are not so strongly calcined.

Some fresh Portland cement, composed as usual of chalk lime and clay, was divided into two portions, one of which was guaged up and left to set under water for six days. The remainder was then dried, and a small quantity weighed and treated for twenty-four hours with dilute hydrochloric acid. The supernatant fluid, containing lime, gelatinous silica, oxide of iron, &c. was then carefully decanted off, to separate it from the clay which remained unattacked by the acid. This could not be done by filtration; as a portion of the silica would have been retained on the filter. The fluid was then evaporated, and the whole gelatinous silica thrown down in a more insoluble form, along with the lime and other impurities: these were dissolved out by hydrochloric acid and boiling water; and, after filtration, the pure gelatinous silica heated to redness, and weighed. Fresh Portland cement treated thus yielded 12·83 per cent. of silica.

The cement which had been set for six days under water was then operated upon in a precisely similar manner, after having been powdered and dried. The cement now yielded 16·70 per cent. of silica,—or 31 per cent. more silica than was obtained from the fresh cement. This proved that a considerable quantity had left the alumina of the clay to combine with the lime, during the six days the cement was under water.

Could the silica be separated from the lime, and not at the same time also from the alumina, by some method in the *dry* way, probably a greater proportion would be obtained between the quantity of silica in each experiment, because in digesting the cement for twenty-four hours in weak acid hydrate of lime was unavoidably formed with excess of water; and the action of the silica had already commenced before the water was evaporated off. But the experiment proved, however, that at all events a large percentage of the silicification of the lime took place in six days after the hydration of it. This taken together with the experiments on the adhesion of mortar, appears to me to furnish strong presumptive evidence of the truth of the foregoing theory.

Although silica is the only direct agent found naturally in limes which enables them to resist the solvent action of water, the question arises, whether any other protection could be furnished artificially, which would form an insoluble salt of lime. From noticing the value of oxalic acid in precipitating lime, with the formation of the very insoluble oxalate of that base, I have been led to try some experiments lately with that acid mixed with the ordinary limes found near Edinburgh. These trials have been attended with considerable success so far as they have gone. A sufficient protection to the lime is apparently afforded to permit of its setting under water, especially when the water used in slaking has oxalic acid dissolved in it. The poisonous nature of the acid, which would require considerable caution in its application, as well as the present price (about 1*s.* the pound) renders the experiments only a matter of curiosity, in this country at least, where naturally hydraulic limes can be easily and cheaply obtained. Nor does oxalic acid appear capable of giving that flinty hardness to lime which is so valuable in the silicate. The adhesion of the lime is also injured by the immediate formation of the oxalate, which has less power of cementation than the hydrate.

The gradual formation of the silicate after the mortar is in the work, along with its increasing hardness, are the properties which make silicic acid so valuable in hydraulic limes.

Before closing these remarks I shall add a few words on the nature of "cements," as that word has been several times introduced.

When foreign matters are present in lime, either from natural or artificial mixture, in larger proportion than about 30 per cent., the lime increases very slightly in bulk and with little heat. Advantage can therefore be taken of the aid which hydration gives to setting, in taking up some of the water of mixture, without fear of the friability and disturbance, which result from the expansion of most limes while slaking. This constitutes what is termed in the profession a "cement," in distinction to a "lime;" but the word is rather an unfortunate one, and gives rise to some confusion, for in the sense of causing materials to adhere together, all limes may be called cements.

From the aid given by hydration, these impure limes set quickly under water; but cements need not therefore be hydraulic, though they usually are. The whole class of plasters and cements derived from the sulphate of lime set at first very quickly under water, from the water of mixture being taken up in hydration, with contraction in bulk; but they are unable permanently to resist the solvent action of the water in which they are immersed.

The hydraulic cements are divided into two classes, the natural and artificial, represented by the two general types Roman and Portland cements. The natural or Roman includes Sheppy, Harwich, Atkinson's, Medina, Lias, and other cements, which differ only in their proportions of lime, silica, and colouring matter. The quickness of set generally depends on the quantity of lime; the eventual hardness, on the silica. The quicker the set, the greater I found to be the danger to the adhesion and permanent hydraulic value, from the greater expansive disturbance of hydration, and from the withdrawal of some of that excess of water of

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mixture, which has been shown to be essential to the perfect action of the silica on the lime.

The cements which are artificially made hydraulic by intimate mixture of lime and clay before calcination, are very perfect when carefully prepared. Both the quickness of set and the degree of silicic petrifaction can be regulated with great nicety, according to the use to be made of the cement, or even the season of the year in which it is required to be used.

INSTITUTION OF CIVIL ENGINEERS.

March 27.—The paper read was "*On Combined Steam.*" By the Hon. JOHN WETHERED, U.S.

It was stated that at the present day the great desideratum in marine engines appeared to be, to obtain increased power or economy in the consumption of fuel, without the commercial disadvantage of occupying more space by the enlargement of the boilers and machinery. This object it was believed had been attained by the application of ordinary and superheated steam mixed. The mode adopted in carrying out this system was, to attach another steam pipe to the boiler, for conveying the steam to be superheated to pipes or other contrivances placed in any convenient form near the fire, or in the uptake or chimney of the boiler, or in a separate furnace; the superheated steam being added to the ordinary steam at or before its entrance into the cylinder. In its passage through the superheating apparatus, that portion of the steam was raised by the waste heat to a temperature of 500° or 600° Fah. The heat thus arrested was conveyed to and utilised in the cylinder, by its action on the other portion of steam from the boiler, which was more or less saturated according to circumstances. The combined steam was used in the cylinder at from 300° to 450° Fah., instead of at the low temperature at which steam was generally employed. The effect of using the two kinds of steam was, that the superheated steam yielded a portion of its excess of temperature to the ordinary steam, converting the vesicular water which it always contained into steam, and expanding it several hundredfold; whilst at the same time, the ordinary steam yielded a portion of its excess of moisture, converting the steam gas into a highly rarefied elastic vapour—in other words, into pure steam at a high temperature.

It was asserted, that repeated endeavours had been made in England, France, and America, to employ steam simply dried, or superheated, and as often abandoned. This plan certainly resulted in partial economy; but owing to the high degree of temperature necessary in this case, the lubricating materials were dried up, and then the packing and rubbing parts of the machinery were destroyed. Moreover, when all the steam was superheated the temperature of the steam in the cylinder was beyond the control of the engineer. It was this difficulty which had led to the discovery of the system of employing mixed steam, which was entirely under control; for by merely turning a valve it could be so regulated as to produce the highest mechanical effect, with the most perfect lubrication to the slides and cylinders. Another advantage was, that if any accident should happen to the superheating apparatus, the cylinders could still be supplied with plain steam alone.

A series of trials on board the R.M.S.S. Avon had shown that the pressure in the boiler being in all cases the same, with plain steam the result was 1070 I.H.P.; with the steam from three boilers superheated and from the fourth plain it was 1076 I.H.P.; while with the steam mixed in the proportions of 61 superheated and 69 plain, 1200 I.H.P. was produced. The Lords of the Admiralty were stated to be so well satisfied with the results of experiments continued over twenty voyages, that they had determined to extend the application of the system in the Royal Navy, and H.M.S.S. Rhadamanthus had been ordered to be fitted with it. Mr. A. C. Hobbs (Assoc. Inst. C.E.) had applied it to a high-pressure boiler and engine, and Mr. Dorman had adopted it to an engine which did not produce the required power. The combined steam was also used in all the steamers of the Collins line. Experiments on board the Gibraltar showed that superheated steam at a pressure on the boiler of 10 lb. produced 222 I.H.P.; ordinary steam at 14 lb. pressure 307 I.H.P.; while combined steam at 15 lb. pressure gave 376 I.H.P.

When steam was merely superheated or dried it was converted into steam gas. It consequently partook of the nature of gas; was a bad conductor of heat, and gave out with difficulty the heat necessary to transform it into mechanical power. On the other hand, mixed steam participated in the qualities of steam proper and of superheated steam, and being a pure highly-rarefied vapour, which readily parted with its heat, thus produced greater mechanical effect.

By the application of combined steam the following advantages among others were said to be obtained:—1. An economy of fuel of from 30 to 50 per cent. 2. A diminution of one-third in the feed-water. 3. The employment of smaller boilers to produce the same power. 4. Facility of maintaining any desired pressure, or of increasing it at will in cases of emergency. 5. A steamer would make a voyage one-third further with the same weight of coals; or one-third the space now occupied by the fuel might be used for freight. 6. Less risk of explosion. 7. Boilers would last one-third longer. 8. A better vacuum was obtained. And, 9. One-third less injection water was required.

April 3.—The entire evening was occupied by the discussion of the preceding paper "*On Combined Steam.*"

In commencing the discussion it was remarked that the indicator cards taken from H.M.S.S. Dee, when using simple superheated steam, and when working with combined steam, the pressure being the same in both cases, and the supply valves equal in area, showed that a better vacuum was obtained and that the expansive force was much greater when using combined steam. It had been ascertained that the consumption of fuel was 2·57 lbs. per I.H.P. per hour with combined steam, whilst it averaged 5·53 lbs. per I.H.P. per hour with plain steam. The result of twenty experimental voyages in that vessel gave, on the combined system 500 H.P., by superheating simply 4·9 H.P., and with plain steam 4·04 H.P.

A case was also mentioned in which combined steam had been applied to a non-expansive engine, where a reduction was effected in the consumption of fuel of from 36 cwt. to 24 cwt. per week; while about one-third less water was consumed.

It was admitted that great praise was due to the author for having recalled public attention to the advantages derivable from superheating steam. But it was doubted whether the combined system possessed any peculiar merit over simple superheated steam. If the mixture were made just at the entrance to the cylinder, it was difficult to understand what difference there could be between that plan, and at once heating the whole of the steam to a uniform temperature. It was questionable whether in a good expansive engine the application of a most efficient system of superheating, that completely prevented condensation, would result in a saving of more than 15 per cent. It was stated that in the early experiments in H.M.S.S. Dee, when superheating was tried, the steam was throttled, owing to the small size of the pipes; and that the apparent superiority of the combined system was due to the large ordinary steam-pipe being in connection with the engines in addition to the superheating pipe, and not from the fact of the steam being mixed. When a different arrangement was made, the superheating gave results quite equal to the combined system.

It was believed that with the best boilers there would be a saving of 15 per cent. by the use of superheated steam; and in one vessel, where there was an indifferent construction of boiler, there was an economy of 34 per cent. due partly to improvements in the boiler, and partly to the application of the apparatus giving more steam room. In one of the vessels belonging to the Intercolonial Royal Mail Company, to which superheating apparatus had been added, the consumption of fuel was reduced from 2,986 lb. to 1,900 lb. per hour on an average of four or five days' steaming between London and Milford Haven. Similarly, in one of the boats belonging to the General Steam Navigation Company, travelling between the Thames and Scotland, an average of twelve voyages previous to superheating showed a consumption of 126 tons of fuel per voyage. This was now reduced to 90 tons per voyage. The temperature in the uptake was formerly about 650°; now it had not been reduced more than 50°, but the temperature of the steam had been increased 100°.

It was remarked that the gain in using superheated steam did not arise from any physical law, but from the prevention of a loss by the use of dense steam. When the steam entered the cylinder, if there was but one degree of heat less in the cylinder, water must be formed. When the vacuum stroke was made, the deposited water, being relieved of the pressure due to its temperature, was rapidly vapourised and passed off as rarefied vapour, cooling the cylinder. On the steam entering to make the return stroke it brought the cylinder up to a temperature due to the pressure, and the stroke was made at that loss by the deposit of water over the whole interior surface of the cylinder and its adjuncts. When the condenser again came into action the same thing recurred, and so on continuously. A pressure indicator applied simultaneously with thermometers, showed that the loss of temperature without working expansively was 20°, with an average pressure of 6 lb., indicating a loss of steam of between one-third and one-fourth. This injurious effect must always occur when using dense steam; whereas, in employing superheated steam there was no deposit of water, and the result was analogous to that of a permanent gas, but with the advantage of easy and complete condensation. Further, when the vacuum stroke was performed, since the cylinder was perfectly dry, the exhaustion of the whole steam was effected instantaneously. With dense steam, the cylinder being wet, the deposited water had to be vapourised and condensed, thus damaging the vacuum. As this action did not occur with superheated steam, some increase of useful effect was produced on that ground. The condensing appliances were also relieved by so much as was gained in the cylinder.

It was believed that the practical limit of the use of superheated steam would be in giving it such an additional amount of caloric as would permit of its remaining dry steam to the end of its required expansion. When steam was expanded a large quantity of heat became latent. In consequence, the full effect was not obtained from expanding ordinary steam, because as it expanded in the cylinder it cooled, and there was not sufficient caloric to keep up the specific heat during the stroke.

It was observed, that the experiments on H.M.S.S. Dee showed a saving of 23·8 per cent. in favour of superheated over plain steam. With regard to temperature, the superheated steam lost 20° on its passage to

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the cylinder, 82° after entering the jacket, and 26° more after entering the cylinder; while the plain steam lost 23° only, after making its entire circuit from the boiler to the cylinder. In another experiment there was an economy of fuel of 20 per cent.; the minimum consumption at full power being 2·6 lb. of Welsh coal per H.P. per hour. It was thought that Mr. Wethered's system was about as economical as the superheated, when the whole of the steam was passed through the superheating apparatus. It was contended, that superheating should not be carried farther than to prevent condensation in the jacket, and therefore in the cylinder; and it was thought, that the whole of the steam passing into the cylinder should go through the jacket, rather than that the jacket should be fed by small pipes.

It was pointed out, that mixing ordinary saturated steam with superheated steam, gave a ready means of regulating the temperature. It was thought, that the increase of temperature should never exceed 100°. If a compensating-rod were introduced into the steam-pipe, so as to limit the admission of steam in proportion to the temperature, beneficial results might be obtained.

In reply to the observations which had been made, it was stated, that it had not been desired to advance any crude theory, but rather to narrate facts. The rationale of the principle advocated had however been given in the paper, nearly in the words of Prof. Regnault, of the French Academy. The difference between superheated and combined steam was stated to consist in this, that superheated steam being of a gaseous nature, was a bad conductor of heat, and parted with it with difficulty; whereas combined steam being pure vapour, and a better conductor of heat, parted with the heat more readily and left more heat in the cylinder of the engine, which was converted into mechanical power. The engineer-in-chief of the United States Navy had proved that there was an economy in the use of the combined steam of 52·5 per cent. over ordinary steam, and 25 per cent. over superheated steam. The experiments conducted under the authority of the Minister of Marine of France, gave nearly the same results, the figures being 52·7 and 24·0 per cent. respectively.

In the British Admiralty yacht Black Eagle, there had been found to be a saving of 20 per cent. in favour of the combined, over the simply superheated steam.

In closing the discussion, it was stated, that the general opinion appeared to be, that the practical introduction of the system of superheating steam was greatly owing to the exertions of Mr. Wethered. He had succeeded in moving the British Board of Admiralty, when perhaps an English engineer might not have been so successful; but this should be a subject of congratulation, as it was desirable at all times to give the greatest encouragement to foreigners, so as always to attract the best talent from other countries. The case did not however seem to be clearly established in favour of combined steam: it rested upon the facts which had been stated, and not upon any scientific explanation of the rationale of the principle, such as would account for the results claimed for it. When more than ordinary attention was given to any machine in daily use, that of itself would often lead to economy. This attention was invariably given when any new invention was being tried, and the whole improvement, or economy, was supposed to arise from the particular modification then being tested.

REVIEWS.

Throndheims Domkirke: or, The Cathedral of Throndheim. The Text by Prof. P. A. Munch; the Drawings by H. E. Schirmer, Architect.—Christiana, 1859.—London: John Weale.

The building illustrated in the above work, which has been produced in a very elaborate and attractive form, under the auspices of the Norwegian government, will be of some archæological and architectural interest in this country, from the fact that the names of its early founders are intimately associated with several of the principal events of the Danish and later Saxon periods of our history; and also from the circumstance that it exhibits English influences as respects its historical progress, if not also the actual workmanship of English hands at this early date. Among the earliest of these founders, speaking with reference more particularly to an original and the immediately succeeding churches at Throndheim—or as it appears to have been then called, Nitharos, that is to say, the Nith's estuary—was Olaf Tryggvason, who is recorded to have built a palace and a church here, dedicated to St. Clemens, or Clement, so early as A.D. 996; the buildings of which however, being of wood, on Olaf's death in the battle of Swalder in 1000, soon fell into ruin and decay. This Olaf, the son of Tryggva, was the grandson of Hacon, called Adelstanfostri, the foster-son of Athelstan, king of England (925—940), and who, having embraced Christianity under the sponsorship of king Ethelred, in whose presence he was afterwards duly confirmed, from a so-called Danish Viking, like many of his fellow Northmen, became associated with the first attempts of this country to introduce the gospel to the then pagan inhabitants of Norway and Sweden. It was at the request of this Olaf to Ethelred, that he would furnish his country with teachers of Christianity, that opened the way for the mission in this direction undertaken during the primacy of Elfric (994—1005), by Sigefried, archdeacon of York; and which was so far successful, that Sigefried died bishop of Wexio, in the province of East Gothland, in Sweden.*

The next is Olaf Haroldson, or the son of Harold (afterwards Saint Olaf,) who soon after 1015 rebuilt the palace and church of Olaf Tryggvason in more substantial form, continuing to reside in the former till his death in the battle of Stikladister, in 1030, his body being in 1031 removed or translated from its first and temporary burial-place, by Bishop Grimcytel, in the presence of king Sweyn of Denmark and Ælgifa his mother, into the church of his refoundation.

The next name is that of Magnus, the son of St. Olaf, who having succeeded in destroying the supremacy of king Sweyn, (established on the death of Olaf Haroldson) over Norway, and restoring the kingdom of his father, naturally, as it is remarked in the historical notice contained in the work before us, "sought to glorify his father's memory, by encircling his remains with due splendour." His first step however, it appears, was directed rather to the embellishment of the tomb in which the body was deposited, contenting himself for the present with the use of the then existing church of St. Clement, in which it lay; but afterwards he began the construction of a church called St. Olaf's church, and in connection therewith a palace, neither of which erections however, though he reigned twelve years—from which we may conclude that the buildings were, like St. Clement's, of stone—were finished on his, Magnus' death, but were completed by his successor Harold Sigurdson—the Harold Harfager or "fair-haired Harold" of English history, the abettor of Tosti, slain with him at the battle of Stanford-bridge.

To this king Harold Sigurdson, who thus next occurs in the list of the early church founders at Throndheim, two other churches owe their origin. It has been before noticed that, in connection with his new foundation of St. Olaf's Church, king Magnus commenced a palace which he left unfinished at the time of his death. A portion of this palace embraced a large stone hall. Abandoning the plan of his predecessor in respect to a palace (the remains of which were subsequently given by his son, Olaf, to his favourite, Sculi, son of the English Earl Tosti), in combination with the church of St. Olaf which he had completed, this stone hall Harold Sigurdson altered, and converted likewise into a church, which he dedicated to St. Gregory, commencing also a new palace for himself, and adjoining thereto another church, which he dedicated to the Blessed Virgin or St. Mary, placing the latter over the spot where St. Olaf's body had been secretly buried immediately after his death. This church, says the work under review, quoting the Sagas, was "a large minster, and so strongly built with lime" (and stone), "that when Archbishop Eystein had it taken down afterwards, it was almost impossible to get the stones from each other." To this new church of St. Mary on its completion, the body of St. Olaf with that of his son, king Magnus, buried in 1047, were removed from St. Clement's church, where they had during Magnus' life and up to that time remained.

At this period then we have the record of four churches as established and existing at Throndheim or Nitharos. 1. That of St. Clemens or Clement, originally built by Olaf Tryggvason of wood, and afterwards rebuilt by Olaf Haroldson in a more substantial form, of stone. 2. That of St. Olaf, founded and begun by Magnus, the son of St. Olaf, also of stone, and completed by Harold Sigurdson. 3. That of St. Gregory; and, 4, that of St. Mary, both also the foundation of the last-named Harold; besides a smaller chapel, which stood over St. Olaf's well, and adjoining St. Mary's church, and which was afterwards included within and superseded by a later church, which ultimately became the cathedral church of Nitharos or Throndheim, the first or proper original of that which the work under notice illustrates. Of this earlier church, Olaf the son of Harold Sigurdson, (surnamed Hinn Kyrri, or the Quiet, from the peaceful nature of his reign,) was the founder. On the death of his brother Magnus, in 1069, this Olaf became the sole successor of his father, and busied himself largely in ecclesiastical matters connected with his kingdom,

* See Churton's 'Early English Church.'

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and particularly in establishing fixed sees there, so, as it is observed, "the bishops should not only obtain a permanent residence, but also cease to be mere court-bishops, and the sanctuaries placed under their care no longer royal chapels, but independent diocesan churches." In carrying out this intention, it is interesting to see how largely, as previously remarked, the reference to England and the English clergy existed at this time. Olaf had probably some reason to be satisfied with the English, as shown in the treatment received by him from Harold after the battle of Stanford-bridge, when he was permitted by the clemency of the conqueror to return to Norway, with the body and the remnant of the army of his father, Harold Sigurdson;—independent of the close ecclesiastical connection between the two countries at this time. The celebrated Turgot, some time prior of Durham, and afterwards (1106) bishop of St. Andrew's, in Scotland, having arrived as a fugitive in Norway in 1069, was graciously received, and attained to high favour with king Olaf, whom he taught to sing the psalms, and with whom he had great influence. This intimate relation of Norway and England in ecclesiastical matters continues to be shown still later. The cathedral of Stavanger, founded during the reign of king Sigurd Magnusson and his pacific brother Eystein, was "dedicated to St. Swithun of Winchester, part of whose relics were kept on a shrine on the high altar," and its first bishop, Reginald, was also an Englishman. Again in 1130, on the assent of pope Eugenius to the formation of a separate Norwegian province, the metropolis of which should be Nitharos, where St. Olaf rested, the legate appointed by him to make the necessary arrangements, and to elect and consecrate the new archbishop, was the well-known Nicholas Brekespeare, cardinal bishop of Albana, also an Englishman.

The Christ or cathedral church of Nitharos was begun early in Olaf's reign. It is expressly stated to have been of stone, and was "so placed that the high altar was directly above the spot where king Olaf was buried, and where the chapel over St. Olaf's well, which now of course was taken down, had hitherto been situated." Into it, on its completion, was removed the shrine of Olaf, and the body of his son Magnus, who it seems had directed that his corpse should always lie near to that of his father;—that of king Harold, Olaf's father, continuing "to rest in the church built by himself, that of St. Mary, where it was buried, after having been carried from England to Norway."

Of this first cathedral church, it is said in the work before us, "we know almost nothing as regards its form and appearance, since it so soon gave place to a new one, larger and more magnificent. It cannot, however, have been very considerable or splendid, since it was completed during the reign of Olaf himself. Thus it can hardly have had more than one nave, and that rather a narrow one, which, as the high altar stood precisely on the same spot as afterwards, probably occupied the same space as the chancel of the later. Being constructed in the 10th century, it must have belonged to the Romanesque style, rather heavy and massive, with a wooden roof except at the eastern apse; it would seem to have had a steeple at the west front." In what manner it was connected, the work goes on to say, with the structure existing above St. Olaf's well, "is difficult to say; in the later church, as will be perceived, the well is comprised within the wall of the polygon forming our Lady's chapel, but in the former church no such chapel is likely to have existed, the space between the high altar and the well, about 47 feet, being unproportionably large. Most likely, therefore, the well had a superstructure of its own connected with the church by a gallery, which seems also to have been the case when only the chapel was there, before the church was constructed."

This church, a portion of the walls of which were it would appear retained "for at least a part of the interior chancel in the later church," remained in its pristine state the cathedral church of Throndheim until the accession of Eystein Erlendsson (Augustine) to the bishopric in 1157, soon after which he appears to have commenced an extensive enlargement, if not entire reconstruction, of the building.

The Engineer's Handbook. By CHARLES S. LOWNDES. London: Longman and Co. 1860.

This is a very handy little book of engineering formulæ, containing a vast amount of information condensed into a small space. There is no attempt at anything like scientific discussion —the formulæ are given dogmatically, but as they are mostly gathered from standard writers on the mechanics of engineering, they may be taken as all trustworthy. The whole style of the book being so thoroughly technical and workshoplike, will be likely to recommend it to the professional engineer in preference to many a more complete and erudite treatise on his art. Formulæ for the strength of square and round hollow columns, proportion of boilers, size of fly-wheels, length and breadth of floats, &c. &c., together with tables of weights of materials, areas, squares and cubes, will all be found here given and explained in simple language, so that anyone may avail himself of the information presented.

The contents of the Handbook are of too miscellaneous a character to be discussed systematically, and furnish subject matter for a detailed review; but we feel that we can confidently recommend it to all engineers, especially to those whose imperfect acquaintance with, or thorough ignorance of, mathematics would preclude them from referring to analytical works; but, to those who can do so, we would endorse the advice given by the author in his preface to the young engineer,—"at his leisure to scrutinize and investigate every rule carefully, either by going down to the principle of it, or by comparing the results obtained from it with the best and most successful examples that come before his notice."

CO-EFFICIENT OF CONTRACTION AT DIAPHRAGMS IN PIPES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR—The formula for the above-mentioned co-efficient, viz. :

$$c = \frac{\cdot 62}{\sqrt{1 - \cdot 62 \frac{a^2}{A^2}}}$$

which is noticed in your review of my work on 'Prime Movers,' is not an error, but an approximation. The exact formula is :

$$c = \frac{n}{\sqrt{1 - n \frac{a^2}{A^2}}}$$

where $n = \frac{\sqrt{5} - 1}{2} = \cdot 618034$.

The approximate value $n = \cdot 62$ is near enough to give that degree of accuracy which can be attained in calculations of the flow of water. I am, &c.

W. J. MACQUORN RANKINE.

Glasgow, 26th April, 1860.

THE SOCIETY OF BRITISH ARTISTS.

IN this, the thirty-seventh exhibition of the society, there is a larger number of works than usual, the general aspect of the rooms looks also better, owing to the majority of the pictures being more or less of one average size. The few architectural subjects in the principal rooms may be easily dismissed, as they call but for passing notice. (41), "A street in Tivoli," gives a glimpse of habitations far dissimilar to the style of the celebrated ruin of the temple of Vesta, which is close by. "Tantallon Castle" (87), is a large and grand picture by Mr. Syer, very ably treated. An old mill near Llangattock, Breconshire (93), J. Tennant, and (332) "a Welsh mill," G. Cole, are two of the many subjects of this class which we see around. Another Welsh scene is (191) "Flint castle," by Mr. Bond, while in (235) Mr. Phillips shifts us to the Rhine, with his "View of Stolzenfels, the palace of the Crown Prince of Prussia,"—a Turneresque picture, feebly painted. Mr. Conway's "Recollections of Waltham Abbey" (244), is hung too high up for examination, but it does not promise much beyond being a distant general view. Mr. L. G. Wood has, as usual, some architectural groupings: (277), "Edward the Confessor's Shrine at Westminster Abbey,"—that oft-told tale;—(477 and 479), views in Calais, and of St. Maclon, Rouen. "Rochester Castle" is another well-known subject, here delineated (318) by Mr. Gegan; and Mr. Barnett gives us "Place de St. Arnaud, Rouen" (376), and (509) "Rue de la Boucherie, Caudebec;" both very interesting pictures.

Venice, of course, is in some way or other represented: we have therefore in (526) a part of the Piazza of St. Mark's, and tower. (571), By Mr. F. Moody, shows the Organ-screen at

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King's College Chapel, Cambridge. The same artist, in (385), has "Side-screen of the choir at St. Paul's Cathedral;" both very well expressed, though in themselves so different.

In the Water-colour Room we notice Miss Edwards' "Dolbadarn Tower, Llanberis, North Wales" (637),—Miss Rayner's only contribution (690), "Street view in Salisbury," one of those studies which she so well knows how to render;—(694), Mr. Varley's "Canonbury House, Islington, before the year 1800," a place full of historical as well as archæological interest;—an unmistakeably architectural drawing by Mr. Macquoid (696) of a portion of "Autun Cathedral;"—and another of the same class (710), the "South entrance to Rouen Cathedral," by Mr. Cole. Mr. Hawkins exhibits, in (755), "St. Alban's Abbey," and Mr. Bayliss (771) the "Lady Chapel, York Minster;"—"Chipstead Church, Surrey," a valuable early specimen, finds a delineator in Mr. Oswald (779), while, in (795), we observe a not very happy "Interior view of Henry VIIth's Chapel," looking westward. Nor is Mr. Bayliss' "St. George's Chapel, Windsor" (828), much more happy, but it is a difficult thing to make a good-looking picture with West's painted window as the prominent central feature. Mr. W. Deane's "St. Pierre, Caen" (838), is an artistic, yet thoroughly architectural view, while the peculiar design of "the Escurial" in Mr. Dobbins' picture (857) is worthy of examination.

Among the general exhibitors we have space only to mention Mr. Hurlstone, the president, who has five pictures;—Mr. J. B. Pyne, who sends but one;—Mr. Woolmer, who has eight;—Mr. Boddington, several;—Mr. Clint, Mr. Vicat Cole, Mr. Pettitt, Mr. Shayer, and Mr. Wingfield.

The collection as a whole is well deserving of a visit.

MAGNETO-ELECTRIC LIGHT FOR LIGHTHOUSES.

Prof. Faraday, in a lecture delivered at the Royal Institution on the 9th of March, says:—By means of a magnet, and of motion, we can get the same kind of electricity as from the battery; and under the authority of the Trinity House, Prof. Holmes has been occupied in introducing the magneto-electric light in the lighthouse at the North Foreland; for the voltaic battery has been tried under every conceivable circumstance, and I take the liberty of saying it has hitherto proved a decided failure. Here, however, is an instrument wrought only by mechanical motion. The moment we give motion to this soft iron in front of the magnet, we get a spark. It is true in this apparatus it is very small, but it is sufficient for you to judge of its character. It is the *magneto-electric* light, and an instrument has been constructed consisting of a number of magnets placed radially upon a wheel—three wheels of magnets and two sets of helices. When the machine, which is worked by a two-horse power engine, is properly set in motion, and the different currents are all brought together, and thrown by Prof. Holmes up into the lantern, we have a light equal to the one we have been using this evening. For the last six months the North Foreland has been shining by means of this electric light, beyond all comparison better than its former light. It has shone into France, and has been seen there and taken notice of by the authorities, who work with beautiful accord with us in all these matters. Never for once during six months has it failed in doing its duty;—never once,—more than was expected by the inventor. It has shone forth with its own peculiar character, and this even with the old apparatus; for as yet no attempt has been made to construct special reflectors or refractors for it, because it is not yet established. I will not tell you that the problem of employing the magneto-electric spark for lighthouse illumination is quite solved yet, although I desire it should be established most earnestly (for I regard this magnetic spark as one of my own offspring). The thing is not yet decidedly accomplished, and what the consideration of expense and other matters may be, I cannot tell. I am only here to tell you, as a philosopher, how far the results have been carried; but I do hope the authorities will find it a proper thing to carry out in full. If it cannot be introduced at all the lighthouses, if it can only be used at one, why really it will be an honour to the nation which can originate such an improvement as this,—one which must of necessity be followed by other nations.

COLONIAL PATENT LAW.

By F. W. Campin, F.S.A.

(Continued from page 118.)

The British dependencies in Europe and Africa not yet noticed are of little importance in an industrial point of view, and have no patent laws of their own, though it appears that a legislative or other ordinance can be obtained. These are Heligoland, Malta, and Gozo, Sierra Leone (expense stated to be £5), Gambia, and Gold Coast.

New South Wales.—The patent law of this colony is contained in the act 16 Victoria, No. 24, which is an act to authorise the governor-general, with the advice of the executive council, to grant letters of registration for terms of not less than 7 and not more than 14 years for all inventions in the arts and manufactures; to have the same effect as letters patent in England, so far as regards this colony. By this act a patentee in England is enabled to appoint an agent in this colony, and on the payment of a sum of £20 may register his invention or patent right, after which he is not liable to any further charge, and is placed in possession of all the privileges to which his patent would entitle him in England. The application for letters of registration is made by petition, which must embody the specification of the invention, and is examined into by persons appointed by the governor, upon whose report thereon letters of registration may issue, which letters of registration must be registered within three days after in the office of the supreme court. Any such letter of registration may be repealed for sufficient cause, that is for the same causes and in the same manner as other grants of the crown are liable to be repealed.

Victoria.—Power to grant patents for any time not exceeding 14 years is given in similar terms to the English statute monopolies: the governor to make the rules for executing this act. On application for the patent the inventor has to deposit the specification and a copy of it, whereupon he obtains six months' interim protection. This specification may however be amended by allowance or requirement of the law officer of the crown before the patent issues. The specification to be according to a form prescribed in the schedule of the act. After deposit of specification and obtaining protection the applicant may proceed to obtain his patent, by giving the requisite notices to the crown law officer, who may then issue the warrant for letters patent. Letters patent may be repealed or withheld, and specification cancelled. Letters patent to be void if the sum of £15 at the third year and £20 at the seventh year be not paid. Disclaimers are allowed. The whole law is an echo of the British patent law, except as regards the schedule of fees, which is as follows: on depositing specification, £2. 10*s.*; to the law officer for any appointment, £2. 4*s.* 6*d.*; on obtaining letters patent, £2. 10*s.*; at or before the expiration of the third year, £15; at or before the expiration of the seventh year, £20; to the law officer with particulars of objection, £2. 4*s.* 6*d.*; on presenting petition for extension or confirmation, £2. 10*s.*; entry of assignment of license, 10*s.*; certificate of assignment or licence, 10*s.*; filing memorandum of alteration or disclaimer, £2. 10*s.*; entering any caveat, at £2. 10*s.*

Tasmania.—The attorney and solicitor general certify that there is no law in force in this colony authorising the grant of patents for inventions within the colony by the local authorities, and as the exercise of that branch of the royal prerogative has not been delegated to the lieutenant-governor by the queen's commission or instructions, patents for new inventions properly so called cannot be granted within the colony. Perhaps an equivalent privilege might be secured to an inventor by act of council, but it is doubtful whether it would not be necessary for the lieutenant-governor to reserve a bill having such an object for the signification of Her Majesty's pleasure, on the ground that it would be an infringement of the royal prerogative; and after going into the difficulties the British patentee would find in getting any protection in this colony, the attorney and solicitor general state that "no sufficient facilities at present exist for rendering a patent granted in England extending to this colony available by proof within the colony, and that if it be deemed desirable to give such facilities, perhaps the simplest mode would be to enact that upon the application of the patentee or his assignee within a certain time the commissioners of patents for inventions under the patent law amendment act 1852 shall transmit or cause to be transmitted the letters patent and specification to the lieutenant-governor, to be sent by him to the

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registrar to be filed in the supreme court, or the transmission might be to the registrar direct, and that such letters patent and specification produced by the registrar shall be evidence in the colonial courts without further proof. The transmission by, as by the authority of the commissioners would be a sufficient guarantee for the authenticity of the documents in all cases, and of course the registrar could not file any but such as had been so transmitted,"—a suggestion which it would be well if acted upon in this and in all our other colonies.

South Australia.—The attorney-general reports that it is not possible to state precisely what documents would be required to enable an inventor or British patentee to make a proper application for a patent right in this colony, because all patent rights are given by the governor and not by the legislature. In practice in the case of an inventor he has been required to give evidence of the originality of his invention, and if a British patentee he has been required to produce an exemplification of the British letters patent; such evidence being given the patent right has been hitherto uniformly secured. There are no official fees, and the expenses of a private act are from £20 to £25.

Western Australia.—There is no ordinance in this country respecting patents; no office for registration, no table of fees, no preventive means whatever against infringement, and but little if any need of them at present. The imperial law prior to 1829 (the foundation of the colony) is of course binding, without the ceremony of adoption. An inventor landing here with a patent and complaining of an infringement must seek redress from the equity side of the civil court by the law as it stood in 1829. In any and every case the burden of proof both of novelty, utility, and originality lies on the patentee. All that essentially makes it valued is done by him at his own cost.

New Zealand.—There are no local laws in New Zealand on the subject of patents, and of course no official fees or expenses required to be paid in any case.

Art Union of London.—The annual meeting was held on the 25th ult. in the Adelphi Theatre. The report showed the receipts by subscription to have been £14,138 15*s.* 6*d.*; and the disbursement—including printing, advertising, amount set apart for prizes, and reserve of 2½ per cent.—to have reached £14,139 14*s.* The reserve fund now amounts to £9,383. The report was adopted; and the drawing of prizes then proceeded.

Testimonial to Mr. C. C. Nelson.—At the meeting held on the 3rd ult. at the rooms of the Royal Institute of British Architects, Mr. Sidney Smirke, R.A., in the chair, on the motion of Prof. Donaldson, seconded by Mr. Godwin, it was unanimously resolved that a testimonial be presented to Mr. C. C. Nelson, as a grateful expression of the high appreciation entertained generally of his very valuable services, the time and constant attention that he has bestowed upon the responsible duties of his office, and of the honourable and courteous manner in which he has, with his colleagues, conducted for ten years the affairs of the Institute. It was further resolved, that each subscription should not exceed one guinea. A committee was appointed to carry out the objects of the meeting.

The Suspension Bridge, Clifton.—Another proposal has been made for completing the suspension-bridge across the Avon, which will unite the two counties of Somerset and Gloucester. This structure was commenced by the late Mr. Brunel more than twenty years ago, and upon it upwards of £40,000 were expended up to 1843. The roadway of the proposed bridge is 850 feet in length, and 220 feet above high-water mark.

International Exhibition of 1862.—The council of the Society of Arts are engaged in forming a guarantee fund, in order to carry out the International Exhibition of 1862. The principal conditions of the guarantee agreement are:—1st, that no subscriber will incur any liability until at least £250,000 have been guaranteed; 2nd, that no calls will be made unless it should happen that, contrary to the experience of the Exhibition of 1851, when there was a surplus of nearly £200,000, there should be a loss, when the call will be *pro rata*; 3rd, any surplus will be at the disposal of the guarantors, for the promotion of arts, manufactures, and commerce; 4th, the trustees and managers of the exhibition named, are the Earl Granville, K.G., the Marquis of Chandos, Thomas Baring, Esq., M.P., C. Wentworth Dilke, Esq., and Thomas Fairbairn, Esq. £170,000 is already guaranteed.

COMPETITIONS.

Architects of Great Britain, Ireland, and France are invited to furnish designs for New Houses of Parliament to be erected in Sydney, New South Wales. £600 will be awarded for the approved design, and £300 for the second best. The style of architecture is left to the competitor. Drawings and estimates to be sent under sealed covers, addressed to the Secretary of Public Works, Sydney, to the care of Messrs. William L. Merry and Co., 36, Cannon-street, E. C. (the commercial agents of the New South Wales Government), for transmission to the colony by steamer. General conditions, together with a contour plan, may be obtained on application to Mr. Weale, 59, High Holborn; Messrs. A. and C. Black, Edinburgh; Mr. H. Campbell, Argyle-street, Glasgow; Messrs. Hodges and Smith, Dublin; Messrs. Philip and Son, Liverpool; Messrs. Thompson, Manchester; or M. Amyot, No. 8, Rue de Paix, Paris. At each establishment photographic views of the locality may be seen. Mr. Weale will give such explanations as may be desired of him by personal application or by post. Designs to be sent in by the 1st of January next.

Designs, with plans, specification, and estimates are invited for a building at Blackburn, to contain a large room for Exchange purposes, a news-room, committee, and other rooms for the transaction of business for the Blackburn Exchange Committee. Premiums £50, £30, and £20. The Exchange will be erected opposite the Town-hall. Plan and particulars may be obtained from Messrs. Hopwood and Garsden, surveyors, Blackburn. Designs to be sent in by the 2nd June.

Designs are invited for a Monument to be raised at Berlin to the memory of Frederick William III. The statue is to be equestrian, in height and dimensions after the model of the celebrated monument by Rauch of Frederick the Great, a copy of which, on a reduced scale, is in the Crystal Palace at Sydenham. The site chosen is between the Royal Palace and the Museum. Sculptors of all nations are invited to send designs. Particulars as to measurement, &c. may be had by applying to the Prussian Minister of Church and Educational affairs. Designs to be sent in by the 15th December next.

Designs are required for thirty almshouses, containing accommodation for thirty poor persons, with a chapel adjoining thereto, to be erected on land belonging to Nappleton's Charity, in the town of Faversham, Kent, containing 2 acres and 19 poles, for the Municipal Trustees of the charities of the borough of Faversham. Particulars may be obtained of Mr. F. J. Giraud, solicitor, South House, Faversham.

Designs are invited from Belgian and foreign artists for the erection of an extensive Bathing Establishment, and the construction of a monument, to be placed near the wells of the Pouhon Spa, Belgium. The estimated cost is 800,000f. The designs to be sent to the Communal Secretary of Spa before the 15th August next. 12,000f. will be divided among the authors of the best designs. The plans will be exhibited in Spa till the end of the season. The programme, topographical maps, price of materials, &c., may be procured for 2f. of the following booksellers:—Wollessi, Spa; Desoer, Liege; Office de Publicité, Brussels; Libraire Renouard, Rue de Tournon, Paris. These documents may also be found at the Belgian Consulates in London, Birmingham, Manchester, &c., and all over the continent.

Designs and estimates are required for laying-out and planting land at Witton, near Birmingham, for the purpose of a Cemetery. The designs must embrace:—1st. A ground-plan of the site, showing the roads and walks, the ornamental planting, the portions to be used for the purposes of interment, &c. 2nd. Sections showing the earthwork required for the arrangement of the surface. 3rd. Such other details as the competitors may think necessary for the guidance of the committee in their selection. The site is about 105 acres, but it is only intended to appropriate 60 acres at first. Premiums £30, £20, and £10. Plans, with contour lines, the sites of chapels, &c., may be obtained of the borough surveyor, Moor-street. Plans, &c. to be sent to Mr. Thomas Standbridge; town clerk, Birmingham, by the 1st June.

Town Improvements at Liverpool.—The Improvement Committee have submitted to the town council a recommendation to carry out an extensive scheme of town improvements, at an estimated cost of £300,000. The plan comprises the widening of many old streets, and the construction of new ones, and embraces the improvement of the approaches to the landing stages. The committee recommended that application be made to Parliament for power to borrow £300,000, the interest upon which would, it was estimated, be met by a borough rate of 3*d.* in the pound. It was stated that, if the scheme was postponed for ten years, the cost would be ten times the amount. The consideration of the subject was adjourned until the report of the special committee appointed to consider the plans for the proposed public offices,—which, exclusive of land, are to cost £100,000—should have been submitted, and approved by the council.

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THE VICTORIA BRIDGE, MONTREAL.

(*With an Engraving.*)

This bridge, which was opened for traffic in December last, is one of the greatest engineering works of our time, and throughout the United States and Canada its completion is regarded as an important event in American history. Its position is half a mile westward of Montreal, a short distance below the Lachine Rapids. Easy communication between the north and south shores of the St. Lawrence; railway connection with the United States, free from the inconveniences of transhipment; and, direct communication with the sea-board of the Atlantic, were imperatively needed.

The St. Lawrence during the summer months opens up the whole of Canada to the ocean, but for the five winter months the river being frozen throughout its course, completely isolates the province. During that season no ships can leave or reach Quebec.

The difficulties of constructing a bridge across the St. Lawrence were considerable—its width at the most available point being very great, and its current rapid and deep. The navigation by steamboats and other vessels, and by enormous timber rafts, had to be provided for; so that unusual elevation and unusual width between the piers were required. In the winter season the field of ice upon the river is from 3 to 5 feet thick, and while frozen the water sometimes rises 20 feet above its summer level. From the thickness of the ice in the middle of the river, little effect is immediately produced upon it by the sun. But the banks of the river, imbibing the heat, melt away the thinner portion of the ice which touches them, thereby depriving the main body of the support it receives from contact with the land. Thus, when a small line of water intervenes between the shore and river ice, the ice begins to move slowly, then more rapidly, until the velocity and power of the current, increased by the melting of the snow, wrenches the ice upwards, and breaks and tears it into fragments, which float down the river in masses, bearing before them almost everything which they encounter. Montreal has especially suffered greatly from this. The ice has burst into that city, broken into the upper windows of dwelling-houses after blocking up the basements for weeks, and forced down river terraces and warehouses erected on the banks. At bends of the river, where the ice meets with obstruction, it sometimes piles itself into icebergs 50 to 80 feet in height. When the river rises, these icebergs get again into the current, and, sweeping along, carry danger and destruction before them.

Under these complicated difficulties the directors of the Grand Trunk Railway, in 1852, sought the opinion of the late Mr. Robert Stephenson, as the engineer most competent to advise upon them. Mr. Stephenson went to Canada in 1853 for the purpose of examining into the facts, which resulted in his recommending the adoption of a tubular bridge, as most permanent, safe, and substantial in such a situation; and to Robert Stephenson is Canada solely indebted for the conception and successful execution of this great work. In May of the following year (after his return to England), he made a report to the directors, the following extract from which will show how much he appreciated the necessity of a bridge:—

"The great object, however, of the Canadian system of railways is not to compete with the river St. Lawrence, which will continue to accommodate a certain portion of the traffic of the country, but to bring those rich provinces into direct and easy connection with all the ports on the east coast of the Atlantic, from Halifax to Boston, and even New York, and consequently through these ports nearer to Europe. If the line of railway communication be permitted to remain severed by the St. Lawrence, it is obvious that the benefits which the system is calculated to confer upon Canada must remain, in a great extent, nugatory and of a local character. The province will be comparatively insulated and cut off from that coast to which her commerce naturally tends; the traffic from the West must either continue to adopt the water communication; or, what is more probable—nay, I should say certain—it would cross into the United States by those lines nearly completed to Buffalo, crossing the river near Niagara."

Up to the period of Mr. Stephenson's report, great difference of opinion existed in Canada and elsewhere as to the probable effect of the ice pressure. Some thought timber casings or fenders, such as those in use on the small rivers of Norway and in other places, would be an efficient protection for the piers of the bridge to be constructed. A proposal was much impressed on Mr. Stephenson to protect his piers by what is called a "crib-work," that is, by large masses of timber in front of the piers, crossed and weighted, and as thick or thicker than the ice itself. It was evident that this extensive "crib-work" must be an additional impediment to the navigation of the river and to the passage of the ice, and Mr. Stephenson was convinced that such a work would be entirely inadequate for the purpose in such a river. "Cribs" he felt were useless, and he adopted stone piers, at wide intervals, each pier having on the side opposed to the course of the stream (which flows here at from seven to ten miles an hour) large cutwaters of solid masonry inclined against the current, up which the ice would creep, as it were, and break itself to pieces by its own weight and pressure. These wedge-shaped cutwaters present angles to the ice sufficient to separate and fracture it as it rises up upon the piers, but so obtuse as not to be liable themselves to fracture. The piers, therefore, were devised to answer the double purpose of piers and ice-breakers; and they have entirely fulfilled all the conditions their originator anticipated, having withstood in the most satisfactory manner the violent pressures which have followed the break-up of the ice.

The superstructure is an elongated repetition of the design for the Britannia Bridge. Its several tubes are not so long as those of the last-named work, but are the longest yet constructed without the adaptation of the cellular principle. The length of the bridge from bank to bank is only 176 feet less than two miles: the Menai Bridge is 1880 feet long;—the Victoria Bridge is therefore nearly five and a half times longer. There are twenty-four piers, with the two abutments, leaving twenty-five spans for the tubes. The centre span is 330 feet wide, and each of the others 242 feet wide. The width of each of the piers is 16 feet, except the two at the centre, which are 24 feet each.

The stone used in the construction of the piers and abutments is a dense blue limestone, partly obtained from a quarry at Pointe Claire, on the Ottawa, 18 miles above Montreal, and partly from quarries on the borders of Vermont, U.S., 40 miles from Montreal. At the foundation-level the piers are 90 ft. from front to back, and from this level the ice-breakers rise with an inclined face of 1 to 1, the upper portion of the piers being 33 feet deep. The blocks were all dressed on their beds, and cut to shape in the quarry, and conveyed by a tramroad, constructed for the purpose, to the shore of the St. Lawrence, and thence by barge to the works. The outside of the stonework is rubble-faced, excepting the quoins and ice-breaker faces, which are dressed. The piers close to the abutments each contain 6000 tons of masonry, those supporting the centre tube contain 8000 tons each. The total amount of masonry in the bridge is 3,000,000 cubic feet, which at 13½ feet to the ton gives a total weight of about 222,000 tons. Scarcely a block of stone used in the piers is of less than 7 tons weight, and many of those exposed to the force of the ice weigh 10 tons. The blocks are bound together by the best hydraulic cement, and each stone is clamped to its neighbours in several places by massive iron dowels, bored several inches into each block, and run with lead.

Each of the abutments is 250 feet long, and 90 feet wide. The north shore of the St. Lawrence is connected with the northern abutment by an embanked causeway, faced with solid masonry towards the current, 1236 feet in length. The causeway from the south bank to the southern abutment is 824 feet long. The distance between the outer or river end of one abutment to the outer end of the other is 6540 feet. The cubic contents of the approach-banks amounts to 200,000 cubic yards.

The average depth of the foundations is about 15 feet below summer level; the bottom being rock covered with about 8 feet of gravel and clay. The rocky bottom, which was at one time thought firm, in many instances has proved to consist of loose boulders of immense size, all of which had to be effectually cleared away before a single stone of the permanent masonry could be laid. One of these boulders weighed no less than 24½ tons.

Of course cofferdams of large proportions were used in the construction of the piers, the internal capacity of each being about 90,000 cubic feet, or nearly 570,000 gallons, which was the quantity of water at first pumped out of them.

The superstructure differs from that of the Britannia Bridge in these respects. The central spans of the Britannia Bridge are 460 feet, while the central span of the Victoria Bridge is 330 feet—its other spans being 242 feet each. The Britannia tube has a cellular top and bottom, but the Victoria tubes are not cellular, in fact they are the largest tubes ever constructed without cells.

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The Victoria Bridge, being for only a single line of railway, has but one line of tubes instead of two parallel lines, as in the Britannia Bridge.

The clear height of the under surface of the centre tube from the ordinary summer level of the river is 60 feet; the height diminishes towards either side with a gradient of 1 in 130, or 40 feet in the mile, so that at the outer or river edge of each abutment the height is 35 feet above the summer level.

The tubes are 18 ft. 6 in. high at the abutments, whence they gradually increase to 22 feet in the centre of the bridge. The width of each tube is 16 feet, or 9 ft. 6 in. wider than the rail track, which is 5 ft. 6 in.—the national railway gauge of Canada. They are all amply stiffened by strong transverse framework at small intervals, and by abundant longitudinal T irons, L irons, and strips.

The plates vary in thickness according to strain, the top and bottom diminishing from the centre, where there is the maximum amount of strain, to the bearings where the horizontal strain ceases, and the plates composing the sides increasing from the centre to the ends.

The tubes were not floated and hoisted as in the case of the Britannia and Conway tubes, but were built plate by plate in their destined position on a rigid timber-stage or trussing, supported by intermediate temporary piers of massive timber. So complete were these huge timber stages, that they really became comfortable workshops for the men, and were fitted up with all sorts of appliances for handling the heaviest portions of the tube with facility. When the last portion of the tube was completed, this mass of timber was cleared away, leaving the tube no other support than that provided for it on the stone pier.

The contraction and expansion of the superstructure has been provided for by the application of cast-iron rollers between cast-iron plates, the upper plates being fixed to the underside of the tubes, and the lower ones bedded into the stone; the tubes being fixed at one end to the piers, and supported on the rollers at the other end. The tubes are designed to be quite independent of each other in resisting the strains, which were calculated for the tubes at the junction of every plate.

Nothing can be more satisfactory than the working of the roller arrangement in providing for the contraction and expansion of the tubes The amount of elongation or shortening of the tubes is easily perceptible at the roller ends, every 8 degrees of temperature making a difference of $\frac{1}{10}$-inch in the length of the 242-feet beams; but the most remarkable circumstance is the effect of the sun in lifting the tubes; the central span, which weighs about 600 tons between its bearings, is lifted up in the middle through a vertical distance of $1\frac{3}{8}$ inch by 80 degrees of heat.

The total weight of iron in the tubes is about 9000 tons. They are bound and rivetted together in the same manner and with the same machinery as at the Britannia Bridge. The bridge is covered by a roof of bright tin, a very favourite material for roofing in Montreal, and one eminently durable in that locality, preserving even its brilliancy for half a century.

The tubes were designed in the office of Mr. Robert Stephenson, in London, and made at Birkenhead, and were prepared and arranged in all their details under the sole superintendence and supervision of his relative, Mr. George Robert Stephenson. Every plate and piece of iron was punched in England before it was sent to Canada, and detailed drawings and instructions were sent to show the method of connection; so that little remained to those upon the spot but to fasten together the various pieces, and place them in their order and position as directed. The total cost of the bridge was £1,250,000.

Previously to its being opened a final inspection of the bridge was made by Messrs. Bruce and Stockman, who, at the desire of the executors of the late Mr. Stephenson, went to Canada for that purpose. Those gentlemen, with Mr. Alexander M. Ross, the engineer in Canada, and Mr. James Hodges, the representative of Messrs. Peto, Betts, and Brassey, the contractors, subjected the tubes to a very severe test; the result of which was highly satisfactory, the tubes having deflected less than they should by calculation. Messrs Bruce and Stocker's reports (to the directors of the Grand Trunk Railway Company, as well as to Mr. Stephenson's executors), are embodied in Mr. Blackwell's general report on the railway. The Victoria Bridge forms an enduring monument in the New World, as the Britannia Bridge and many other noble works do in the Old, to the fame of Robert Stephenson.

ARCHITECTURE AT THE ROYAL ACADEMY.

A change has indeed come over the spirit of the Exhibition this year! Instead of the over-crowded pictures, their number is reduced to a reasonable list, and what space is left on the walls above the range of pictures is judiciously arranged in festoons of drapery. Miniatures are scarcely visible at all, there being but two small desk-tables in one room appropriated for their reception, instead of their entering an appearance by hundreds as of yore—thanks, among other things, to photography;—architecture has been shifted to another apartment, and shares possession also of the entrance staircase;—with sundry other deviations from routine, of less significant import.

It is generally considered, we believe, that, as a collection, it is above the average, and in the architectural department it is most certainly so. Indeed, out of upwards of a thousand works admitted by the magnates of Trafalgar-square more than a tenth are "architectural"—an unprecedented proportion, we imagine; and it may be added with pride, that there is scarcely one of these that does not well deserve its place. Still, in the architectural, no less than in the painting department, many of the great names of the profession do not appear among the exhibitors. Of the Academician architects and associates Mr. Smirke's is the only one in the catalogue, while the rising members of the profession muster strongly and ably too. We are glad also to welcome an accession of new names, and trust that the present is the inauguration of a more healthful state of things, and that architecture will eventually recover that position from which for many years she has been gradually and, as it seemed to threaten, hopelessly lapsing.

The selection of the few architectural pictures which are hung on the somewhat dark landing is, on the whole, perhaps as good as could be made,—size of frames and tone of colouring being accepted as criteria. Thus, the "Cathedral, Wells" (617), by Mr. Stockdale, is shown in a noble exterior view, taken almost directly west, and with the glowing effect of the setting sun upon the venerable pile. It is grandly massed, and in admirable keeping throughout. "The tomb of Henry V., Westminster Abbey" (619), is a hackneyed subject, here not particularly well handled. (618) "Opéras," a residence being erected in Sweden from the designs of Mr. W. A. Boulnois, is a very good Italian design, in which a low tower is introduced with happy effect. "Tonbridge school Chapel" is, if we mistake not, a new building; but we cannot congratulate Messrs. Wadmore and Baker on either the roof or the seating, both of which look poverty-stricken in the extreme. Mr. R. W. Billings shows in (621) the "Gateway and staircase to the porter's lodge at Kemble, Gloucestershire," erected from his designs; and characterised by that boldness of idea and construction with which that gentleman's works are invariably imbued. The entrance itself is under a large segmental arch, and there is a curiously-contrived staircase by the side which has a very picturesque effect. Another of Mr. Billings' powerful drawings is (654), the "Entrances, balcony, and flanking turret at Dalzell Castle," conceived in the same spirit as the former one; and the third is a "Restoration of the Governor's house at Stirling Castle," as rebuilt after the recent fire. (622) We at once recognise as proceeding from Mr. I'Anson, since it smacks of that peculiar phase of continental architecture with which he clothes the majority of his works, and in this case, it must be allowed, with especial success. The drawing is a thoroughly architectural one, embracing in one frame an elevation, interior view, and parts at large of the new "Corn Exchange Chambers, Seething-lane, London." The interior of the subscription-room strikes us as being a felicitous treatment of a not very easy subject: the way in which the lighting is arranged, as well as the subdued colouring on the walls, are especially noticeable. Another excellent specimen of coloured decoration is afforded in the adjoining picture (623), in which Mr. Beavis shows a handsome ceiling for the drawing-room at Torry Hill, near Sittingbourne. In this the subordination of certain parts, so as to conduce to general rather than individual effect, has evidently been studied with care. To the title "Wellington Church," which is appended to (624), Mr. Cuff should have added the word *tower*, inasmuch as that only is shown, and, moreover, imperfectly.

Two bird's-eye views of Messrs. Green and De Ville's designs for the prisons at Gènes and Turin (625, 626) are the only exhibited results we have seen of the late Italian competition. They are designed on the radiation principle, and appear to be well devised, though there is no plan to inform us as to minor arrange-

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ments. The materials are light brick, relieved by red and black banding, and a suitably severe character is imparted to the various masses. A fine view of the "New Royal Dramatic College, at Mayberry, near Woking," and ofwhich the Prince Consort is to lay the foundation-stone to-day (June 1st), earns the distinction of being by far the largest picture of its class in the Exhibition. As we shall have occasion to notice this building specially, we will only say that, regarded pictorially, this forms one of the most striking pictures on the walls. There are some good points in Mr. Robins' "Croydon Cemetery Chapels" (628), but withal no great novelty. The best idea is the position and management of the tower, in itself rather too large.

It is perhaps not easy to pass an opinion on the "Lunatic Asylum for the colony of New Zealand" (631) from the drawing here shown, without any plan; it is built half-timbered, and, according to our notions, is totally devoid of character. An Italian "Design for a mansion near Rouen" (635), may be cited as a successful adaptation of Classic and Continental. The architect, Mr. Barber, uses French roofs, and has added a lofty tower, which increases the play of outline surprisingly. Mr. R. M. Phipson, in the "Holbrook parochial schools" (636) now erecting, offers about as tame and unmeaning a mass of red and black brickwork as we have seen for some time. There is not a spark of originality in it,—at any rate of the right kind. Premising that the drawing is rather over-laboured, we give unqualified approval to Mr. Pope's "Hospital at Hemsworth, county Cork" (637), founded originally in 1555, and now being rebuilt. The several parts of a very clever design, Domestic-Gothic in character, are shown to be well worked out, and tastefully grouped. In neither the "Residence at West Broyle" (638), by Mr. Teulon, nor the "Calthorpe Lodge" (639), by Mr. Freud, is there anything to call for special remark; and we therefore pass on to (640), which shows with elaborate minuteness Capt. Fowke's "Suggestions for a public road, to connect the districts north and south of Hyde-park," without interfering with the Rotten-row ride, the drive, or the walks in the park and gardens. By this scheme, which appears to meet a great desideratum, and to obviate most of the difficulties, the road will run for almost its entire length in the sunk fence between the park and Kensington-gardens; and, at the Serpentine bridge, the only point at which it appears, it would be perfectly separated and shut out from the promenade in the gardens, and made to add to the effect of both that of the bridge and the surrounding scenery. The proposed promenade would rise 1 in 114, and communicate with the banks of the river by means of terraces.

In the "Staircase at Gayhurst, Buckinghamshire" (643), Mr. Burges has skilfully secured a highly effective amount of picturesqueness. It may be urged that the Elizabethan style, which is used, favours this result; still how often do we see its quaint oddities vulgarised, instead of, as in this case, understood in feeling, and improved upon in practice. As a study of colouring, this drawing, which has the name of E. S. Cole in the corner, ranks high. (644) Being the handiwork of a lady, must be regarded accordingly. Were it otherwise we should be apt to find fault with the insipidity and want of nerve which it manifests. As, however, Miss Weslake has evidently accomplished a *con amore* task, we can forgive these drawbacks, and praise the fidelity and care displayed in a not very genial subject—the tomb of the late Mr. George Gwilt, F.S.A., in the churchyard of St. Saviour's, Southwark, with whose lady-chapel his name will be ever remembered as its faithful conservator and restorer, at much personal sacrifice, and at a time when Mediæval architecture was comparatively little understood or practised. The Church and Parsonage of St. Stephen's, South Lambeth, by Mr. Barnett (645), is one of those tame and common-place designs which are now all but exploded. It is totally devoid of interest. "Llandaff Cathedral," the west front of which is shown in Messrs. Prichard and Seddon's drawing (647), has been under the restoring hands of those gentlemen for some years; and we here see the proposed south-west tower and spire. In the absence of direct information we must conclude that for its design there is sufficient warrant, in the shape of existing remains or other data, otherwise we should at once question the propriety of erecting a steeple in all respects so thoroughly church-like on a building of this description; the new tower being, moreover, so utterly at variance with its opposite neighbour on the north-west. Mr. Street's "Design for a monument to Major Hodson" (648) is a coped tomb with a cross on the top. It has three sculptured panels at the side, and two at the end. The centre represents the gallant soldier receiving the submission of the princes of Delhi, and between this and the angles the panels are illustrative of the cardinal virtues. There is an inscription and a slight introduction of inlay work in the lower part. In (649, 652) are shown an exterior and interior of his church about to be built at Cowley, of which another view has been published in this Journal. We would call attention to the general design of the interior, and especially to its beautiful roof and the surface ornamentation of portions of the stone work.

"The shops recently erected at Folkestone" by Messrs. Walton and Robson, are unworthily represented in (653)—coarsely drawn in sepia; and much as we deplore the present condition of St. Margaret's Church, Westminster, we doubt whether it would be in any sense improved by the restoration (?) proposed by Mr. Ashpitel (650), of which another view was exhibited some time ago. It appears that this church was originally built by king Edward the Confessor, the founder of the adjacent Abbey, and that it was rebuilt a short period before the erection of king Henry VII.'s chapel. About 120 years ago the entire original surface was stripped off, and the present Batty Langley casing substituted. Mr. W. M. Teulon's "National schools for Llandilo" (655) are well grouped, and the partial use of half-timbered work is in this case advantageous. (656) The "Interior of the new Roman Catholic church at Lanark," may rank among Messrs. Hadfield and Goldie's best productions. The roof is curved, and boarded underneath throughout with panelling and decorative patterns.

THE LATE SIR CHARLES BARRY, ARCHITECT.

ANOTHER name has been struck from the list of the celebrated men of our age. Within the brief space of a few months Brunel and Stephenson, the eminent engineers, and Macaulay, the eminent essayist and historian, have been taken from amongst us; and on Saturday evening, the 12th ult., Barry, the most successful of English architects of the present day, breathed his last, at the age of sixty-five years.

We must express our deep regret for the loss which the profession to which he belonged, and all lovers of architectural art, have thereby sustained. Barry was unquestionably among the ablest of the architects of the day, and in the course of his career has contributed extensively, as observed by one of our contemporaries, both "by works, by teaching, and by example," towards the development of our architectural progress.

Unlike Inigo Jones and Wren, the former of whom was originally a painter, and the latter a mathematician and astronomer, Sir Charles Barry was from the commencement of his career trained to the profession of an architect, and devoted himself enthusiastically and untiringly to the acquirement of the knowledge requisite to fit him for the duties of his chosen pursuit. His father, it would seem, was a respectable stationer in Bridge-street, Westminster, where Barry, it is believed, first saw the light on the 23rd of May, 1795. His education was commenced at a private school in Lambeth, and completed in Leicestershire, where, like many other great men, he merely learned "a little Latin and no Greek," in addition to the usual courses of a middle-class tuition in those days.

On leaving school young Barry was articled to Messrs. Middleton and Bailey, surveyors, Lambeth, with the former of whom he was an especial favourite. On the expiration of the period of his articles, in 1817, against the remonstrances of his friends, he resolved to travel abroad, with the view of preparing himself more effectually for the ultimate prosecution of his profession. After travelling through France he proceeded to Rome, where he met the present Sir Charles Eastlake, Mr. Kinnaird (the editor of Stuart's 'Athens'), and other kindred spirits, and also a generous patron, in the person of Mr. Baillie, a gentleman of fortune, who engaged him as his travelling artist. With this gentleman he visited Constantinople, traversed Asia Minor, Syria, Palestine, Egypt, and other parts of the East, afterwards returning to Rome, and thence to England, his portfolio filled with innumerable sketches of a high order of excellence.

After an absence from England of nearly four years, Barry returned to commence the serious business of his profession. His first works in architecture were St. Matthew's Church, Manchester, and another at Stand, in the neighbourhood. Of nearly the same date was the erection of St. Peter's Church, Brighton—wanting a feature of the original design, the spire, which has not since been supplied. One or all of these works be

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had obtained by competition not long after his return. Soon afterwards the late Daniel Wilson gave him three churches to erect in the parish of Islington,—Ball's-pond, Cloudesley-square, and Holloway. His next work to those above mentioned would seem to have been an Unitarian chapel at Manchester. All these were of Gothic design, a style in which, however, at this time Sir Charles does not appear to the same advantage as he does in his later works of the same character. Sir Charles's earlier aspirations and acquirements had evidently greater reference to Classic than to Mediæval models. He is reported in the first periods of his study to have "cared for little but Greek, concerning which he was enthusiastic." His observation of Roman and Italian architecture, however, was very largely and energetically carried out—with what result the evidences he has left us in the Travellers' Club, and other buildings of the Classic and Italian type, will sufficiently and satisfactorily show. Barry, there can be but little doubt, was *par excellence* of the Classic school, notwithstanding that the versatility of his genius, and the power he possessed of infusing art and propriety into all his works, enabled him to succeed above most others in the style not so distinctively his own. In the latter, or that of the majority of his works, none have surpassed him; while, with respect to his great Gothic work of the Houses of Parliament, few who recollect the exhibition of the competitive drawings will hesitate to indorse the sentiments of the Commissioners appointed by the Government to examine the several designs submitted, as expressed in their report thereon. These Commissioners, as will be remembered, were the late Mr. Hanbury Tracey (afterwards Lord Sudeley), Sir Edward Cust, Mr. Thomas Liddell (an excellent amateur architect), and Mr. George Vivian. The words of the report were as follows: "Although a difference of opinion may exist between us with respect to the ground-plans, separately considered, we are all unanimous in our opinion that the one delivered to us marked (64), with the emblem of 'Portcullis,' bears throughout such evident marks of genius and superior talent, as fully to entitle it to the preference we have given it in our classification; and we have no hesitation in giving it as our opinion that the elevations are of an order so superior, and display so much taste and knowledge of Gothic architecture, as to leave no doubt whatever in our minds of the author's ability to carry out your Majesty's commands."

While on this point of the Gothic design of Barry for the Houses, it is to be remarked that it has been considered Sir Charles was much aided in this matter by his association with the late Mr. A. W. Pugin, with whom he had a long preceding intimate connection. Believing such to have been the case, it is certain that Sir Charles never sought to contravene this impression, but, with the urbanity and modesty inherent in him, as in all men of true genius, always willingly acknowledged any assistance he received.

Some of the earlier works of Sir Charles Barry we have previously enumerated. Among others of his later and principal ones may be mentioned, the Royal Institution, Manchester, about 1828; the Travellers' Clubhouse, London, 1831; the Grammar School, Birmingham, 1833; Trentham-hall, Staffordshire, 1833, and Clifton, Berks, alterations and additions; Bowood, alterations and additions, for Lord Lansdowne, 1834—38; College of Surgeons, London, alterations and additions, 1835 to 1837; Athenæum, Manchester, 1836—39; Houses of Parliament, commenced 1837; the Reform Club, 1837; Stafford-house, St. James's, alterations; Harewood-house, near Leeds, alterations and additions; Shrubland-park, Suffolk, for Sir W. Middleton; Duncombe-park, for Lord Feversham; High Clere, for the Earl of Caernarvon, alterations, 1840; Gawthorpe-hall, alterations, for Sir James Shuttleworth; University College, Oxford, additions, 1840; the Treasury buildings, Whitehall, alterations; Bridgwater-house, St. James's, 1847; Dowlais schools, &c.; to which a still further number might be added, Halifax Town-hall being among the last upon which he was engaged.

The following have been given as the societies, &c. of which Sir Charles was a member at the time of his death:—the Royal Academy of Arts, the Royal Society, the Institute of British Architects, the Society of Arts, the foreign Academies of Rome (the San Luca), of Stockholm, Antwerp, Belgium, Prussia, Russia, and Denmark, and the American Institute of Architects.

The interment of Sir Charles Barry took place on Tuesday, the 22nd ult., and it is gratifying to the profession as well as to his friends to know that his body rests where he himself would probably have most desired, and under the shadow of his most important and engrossing work: it is deposited in the nave of Westminster Abbey, close by those of Telford and Robert Stephenson. His funeral was very largely attended. Independently of the House of Commons, represented by Lord John Manners, and other members, all the great societies of art and science, in the persons of their chief members, were likewise present to pay the last tribute of respect to his remains. Of the council and members of the Royal Academy, as well as of its associates, there were all the most distinguished names. Of the council and members of the Royal Society, and of the Royal Institute of British Architects, and the Institution of Civil Engineers, there were in like manner many of the most distinguished. The Society of Antiquaries, the Society of Arts, and the Society for the Encouragement of the Fine Arts, &c., were also duly represented. There were also many of his patrons and of his admirers in and out of the profession, besides a large body of the workmen who had been employed under him, who had joined the funeral procession as it approached the Abbey. The burial service was most solemnly and affectingly performed; and it will be very long ere those of the profession as well as others who were present will cease to remember the scene exhibited and the effect produced on the occasion of the burial of Sir Charles Barry.

He leaves, we believe, five sons, two of whom are in the same profession as their late father, viz. Mr. Charles Barry, of the firm of Banks and Barry; and Mr. Edward Middleton Barry, the architect of the new Italian Opera-house and Floral Hall, Covent-garden.

SUBMARINE TELEGRAPH CABLES.

During the abeyance of all such projected schemes since the Atlantic cable was designed and lost, a great reform in the method of constructing submarine ropes has been going steadily forward. The old principle of ponderous iron coils for deep-sea wires has been so generally abandoned, that a proposition for now reverting to their use across a sea of any length or depth would not be entertained by telegraphic engineers, excepting in situations where, from the possible anchoring of vessels, any risk of fracture exists. The results of this alteration in the weight and strength of cables are likely soon to be practically tested on an extensive scale, by the success or non-success of two cables now being manufactured in England. The first of these is to connect Rangoon with Singapore, and is of the old construction, differing principally in the conductor (consisting of seven wires in immediate contact with each other), being much larger than any hitherto used. The other, which is to connect Toulon with Algiers, is about the lightest cable of its kind that has ever been made, excepting the gutta-percha covered copper-wire which was stretched across the Black Sea to Balaclava. These cables are in progress of manufacture at Glass, Elliot, and Co.'s works, East Greenwich, for the English and French governments respectively, and will, it is hoped, before next winter be successfully submerged.

The New Library and Reading-rooms, Melbourne, Australia.—This structure, which will be large and commodious, is designed in the Classic style, by Mr. Smith, jun., architect, formerly of London, but now settled in Australia. The three principal rooms in the building measure respectively 60 feet by 40 feet, 40 feet by 30 feet, and 40 feet by 25 feet. An excellent collection of sculpture, about to be forwarded to Melbourne for the embellishment of these rooms, may now be seen in the studio of Mr. Brucciani, in London, by whom they have recently been executed. The principal works are,—the group of the Laocoon, the Apollo Belvedere, the Antinous and the Dying Gladiator, from the Vatican; the Listening Slave and the Venus de Medici, from the Tribune at Florence; the Diana of the Chase, Masaniello and the Diana Robing, from the Louvre at Paris; and the Illyssus, from the Parthenon. There are some admirable bassi and alti relievi from Michael Angelo, Lorenzo Ghiberti, and others of the modern Italian schools; and *chefs-d'œuvres* after Thorwalsden and Canova—the noted statue of Perseus by the latter, and busts of Milton, Shakspeare, Schiller, Goethe, Buffon, Voltaire, &c. This fine collection will be acceptable to our countrymen in Melbourne; and the desire to possess them is a gratifying evidence of their appreciation of high art.

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THE ARCHITECTURAL EXHIBITION.

(*Concluded from page* 126.)

Messrs. Judge and Winstanley's competition design for the enlargement of the Orphan Working School (79) is very tame, and rightly deemed unfitted for its intended purpose. Mr. W. White's only two drawings represent the interior and exterior of a "New district church at Newquay, Cornwall." These have been widely separated, by some oversight we presume in the hanging, their numbers being (84) and (289). The building consists of only nave and chancel, and is treated in the simplest manner, even to an extreme; the chancel arch does not seem to have even a single shaft or chamfer, but to have a mere square soffit all round. Of Mr. Marsh's two sketches (86, 87), we prefer the second, showing the north porch of Selby church. This is curious, and has but rarely been published; it presents in the same elevation features appertaining to the Norman, Transition, and Perpendicular eras.

Mr. C. Gray, a steady friend to the Exhibition, has this year but one drawing (90), but that is a good one. It is catalogued "Design for chapel of Holy Trinity, Knightsbridge," and consists of four drawings, treated with a masterly hand. Two of these are exteriors, and two are alternative designs for the interior. The style is "Italian Gothic," and is noticeable for the peculiar construction of its roof, and its galleries. (91, 92) Buildings at "Abingdon cemetery," by Mr. J. Brooks, have a certain degree of picturesqueness of plan, but nothing besides. The tinting is painfully laborious and ineffective. The "Offices and sale-rooms, Mincing-lane" (95), just completed from Mr. J. Whichcord's designs, are an important acquisition to our London street-architecture. The style is pure Italian, and the leading lines of the composition are distinctly preserved throughout. Next is a very careful coloured drawing of a "Modern pavement in the Sainte Chapelle, Paris" (96), by Mr. T. Vaughan. It is of very elegant conception—the scroll-work in particular—and is due to the inventive skill of M. Stunnal. Mr. Vaughan has several other sketches from continental examples (112, 113, 115, 116, 117, 269), all marked with that painstaking, careful quality, which is an earnest of their fidelity. He has yet to gain the true *artistic* touch. In the sketches of Mr. Eastlake we find all these combined with unusual facility of expression, as his numerous contributions, also from continental sources (97—109), will testify. The pulpit in Siena Cathedral is charmingly given in the first of these pictures. We mention (114), a "Design" for a town-hall, merely to protest against such wretched attempts occupying room which might easily be better covered.

The eccentric look of (119) is to be accounted for by its subject —"Waterworks in progress at Caterham, Surrey," by Mr. Drew. The principal building shows a strange outline, no doubt accommodated to the requirements within. It is wholly of red and black brick, and, though quaint, by no means ugly. In a very different style are the "Proposed new offices of the National Provident Institution," W. C. Reid, of which two elevations, carefully delineated, are shown in (120, 121). The prominent feeling throughout is Renaissant, and it appears to have been well studied in detail. A perspective view would show the design to greater advantage. The proposed alterations and additions to the town-hall at Ashton-under-Lyne (122), by Ford and Meyer, are ill-proportioned and otherwise unsuitable. The original building, we recollect, is a very good-looking structure. (123) "The premises of Messrs. Hunt and Tanner, 215, Upper Thames-street," do not call for special remark, being of ordinary character only, albeit free from the fancies which under the name of originality are too often perpetrated. The next drawing (124), by Mr. G. Morgan, which shows "The studio and residence of J. R. Swinton, Esq., Warwick-square," is however equally simple, but more characteristic: indeed, the architect may be congratulated on the success of the result throughout, which is neither more nor less than it professes to be.

Mr. J. K. Colling has two or three very good drawings of works now in progress under his superintendence. (127) "Alterations in the residence of Mr. Bass, Rangemoor Hall, Staffordshire," is one of these. The house is of the Palladian type, of red brick with stone dressings; the high mansard roofs are so treated as to add becomingly to the outline of the mass, which is further varied and improved by a bold square tower attached to one corner of the building,—a plan which Mr. Colling has already, we believe, carried out in Mr. Naylor's mansion, at Hooton. The "Schools at Haslington" (128), by the same architect, depend for their good effect entirely upon their general grouping and proportions: the materal is red brick. Two other drawings (185, 186), are interior views of the sculpture and picture gallery in Mr. Naylor's house, just alluded to. The sculpture gallery measures 200 feet by 21 feet, and the picture gallery 78 feet by 28 feet. Considerable richness is imparted to the effect by the introduction of columns of polished red granite, with white marble bases and black marble plinths, also by the floor of oak parquetry. The "Middlesex Industrial Schools" (130), recently completed by Messrs. Banks and Barry, are a very extensive series of buildings, plain, but pleasingly arranged. They are situate at Feltham, and will accommodate 800 boys. In the adjoining drawing, "Schools proposed to be erected for the Plaistow and Victoria Docks Mission" (131), the same architects have not been so successful;—the Tudor style, which they have there essayed, is but feebly treated.

(132) "Trèves Cathedral," by Mr. F. Wallen, is one of those scratchy daubs which should have been altogether excluded from these walls. In (133) Mr. W. G. Smith has a very elaborate design for a Drawing-room Clock, in copper gilt. Its fault is over-exuberance, and though the parts when analysed evidence much taste, the *tout ensemble* is not quite the thing. There are various designs for Drinking-fountains, as might be expected; two of these also (138), are sent by Mr. Smith, which are overdone in quaintness; two others (139, 140), by Mr. Stapleton, jun., are not at all satisfactory; and Mr. F. Wallen's (141), the least so of all. Mr. J. M. Hooker, in his designs for schools at Marden (134), and Charlton (136); as also in (135), "Parsonage-house at Brenchley," and (178), "Abel Smith's Memorial School, Hertford," shows what may be done with very ordinary materials judiciously disposed. These are some of the best designs of the kind in the exhibition.

Mr. Goldie again appears in (143), as contributing "Six studies for the new Roman Catholic church recently completed at Lanark," and in (144), "Six sketches for works in progress." These are but roughly indicated in pen-and-ink, but show that their author bestows due study in the preparation of his details. The "Lanark pulpit," and the "Interior of a church at Ipswich," are among the best of these sketches. The very handsome row of mansions erected by Mr. Tarring in Gore-road, Kensington, are well rendered in (146); they are some of the best designed as well as largest houses which have been done of late.

Designs for and drawings of Schools are liberally scattered over the walls this year, indeed so much so that we shall enumerate as we pass along only such as present any unusual features. Thus (152) Mr. E. W. Godwin's proposed National schools, St. Philip's, Bristol, as an architectural composition appears to us to possess great merit; there is a boldness of outline and due relation of parts, coupled with details well adapted to the materials, which are characteristics of true design: still it may be questioned whether the lofty tower and one or two rather ecclesiastical-looking bits are quite in keeping with "school" buildings. The walling, it may be observed, is of rough Stapleton stone, and in the dressings Bath stone and Bristol red are employed with judicious taste. The roof is covered with Bridgewater tiles. (150) "Penge school," now erecting by Mr. E. Nash, is marred by an unsightly three-light window on the slope of roof. "Markham-square Congregational chapel" (154), we mention only to observe that it is about as hideous a specimen of would-be-Gothic as can be imagined. Its author, Mr. Tarring, has succeeded somewhat better in the adjoining picture (155) "Tingewick Rectory, near Buckingham," a plain Tudor building.

Mr. Phipson's "Library fireplace, Brandeston hall, Suffolk (156), carries us back to Jacobœan times, and is a successful enlargement and completion of the original design. The woodwork is very rich and characteristic. In (158) we have Mr. Norton's "Schoolhouse and residence at Stogursey," particularly sparkling in its grouping and effect, and which pleases us better than his church at Bedminster, of which an exterior view appears in (157). Internally, however, much has been accomplished by the architect, as we have on a former occasion remarked in connection with the perspective view. We are sorry we cannot compliment Mr. H. H. Collins on his curious intermixture of styles in the "Sketch of synagogue (160) now erecting in Upper Bryanston-street, Bryanston-square;" (161) shows the interior, which, among other venturesome absurdities, displays the two rows of principal arches, with the walls above, resting apparently upon slender iron columns! Both drawings are badly executed.

Mr. H. Hall has two unpretending but good "residences" (163,

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164); while Messrs. Walton and Robson, in (165) exhibit "Shops at Folkestone," and in (345), "Messrs. Shield's shop, Durham" (photograph),—both excellent specimens of street architecture, and distinguished by considerable freshness of idea. Their remaining picture (327) is also a photograph—part of the "Depository of testamentary records, Durham,"—very nicely detailed. Some of Mr. J. G. Stapelton's designs are praiseworthy, but those for the chapels at Wandsworth, Cobham, and Littlehampton (166, 167, 168), are not quite up to the mark. At Hersham this gentleman has "restored and repaired" a circular chapel, and has perhaps made the best of an unaccommodating form;—a view is given in (170).

St. John's chapel, Bedford-row, has lately been levelled to the ground, and those who remember that quaint but interesting old edifice will be indeed surprised at the contrast presented in the design for the rebuilding which has emanated from Mr. Garling (173); not that it is in itself by any means objectionable, being in reality a very fair scheme for a town church, with a commendably studied tower and spire at the most important angle. There are no buttresses to the aisle, and the east end is terminated apsidally, which has the effect of depriving the church of that length which under the circumstances could ill be spared. "An experiment in Columniation" (174) is one of those whims which could proceed only from Mr. Leeds, whose services as a writer have been far greater than as an originator. The vigour and richness of Mr. Callow's picturesque "Old houses in the Rue aux Fêves, Evreux" (175) are a delightful change from the insipidity of the last-mentioned drawing. Mr. Callow is essentially an *architectural* artist, and we should have welcomed other contributions from the same individual in this as well as other exhibitions.

Mr. Hans Price, in (176), shows some good plain "Schools at Weston-super-Mare;" though we think we recollect an almost identical tower on a similar building from another hand. The view of "Lamsford Church, Herts" (179), by Mr. D. Brandon, owes more to the tinting of the drawing than to its intrinsic merits, while, for (180), "Design for library, in oak and bronze, for Sydney," not a word can be said in praise of either. We presume that Messrs. Arrowsmith, whose name is appended as sending the drawing, are only the practical carriers out of the design, which is about as complete a specimen of modern upholsterers'-Gothic as the warmest follower of Batty Langley could desire. (182) is a photograph of a "School and mistress' house," erected near Leeds by Mr. Corson, whose buildings are never devoid of suitable character. The walls are of Woodhouse stone, pitch-faced; the dressings of Meanwood stone, boasted, and the roof of Staffordshire "terro-metallic" tiles;—the cost being about £680. Mr. Corson's "Porch at Grove-house, Leeds" (183), is built of Gipton Wood stone, and is in the Italian style with a semicircular stone roof concentric with the arched head of the entrance doorway,—a novel but not very pleasing idea. A series of five photographs in (184) exhibits Mr. Burges' proposed cathedral at Brisbane, Australia. A glance at these will suffice to show that their author is not an ordinary man, but one who, from the fact of having thoroughly mastered what he attempts, has the boldness to throw aside the trammels which are too often allowed to embarrass the architectural designer, and is thereby enabled to produce legitimate and genuine originality, which characteristics are notably observable in the plan, sections, and elevations before us. The same versatility and ingenuity are noticeable in Mr. Burges' "Designs for drinking-fountains," as shown in (239), and which are decidedly among the best of their class. As specimens of modern stone carving—an art not yet thoroughly understood—we hail with satisfaction those lately executed at the offices and sale-rooms, 9, Mincing-lane, by Mr. Tolmie from the designs of the architect, Mr. Whichcord, jun., as among the best in the Classic style; these are well shown in the photographs of (187); likewise in the Mediæval style, Mr. Forsyth's sculpture in the reredos of Sherborne Abbey church (209, photograph), designed by Mr. Slater, which consists of four subjects, beautifully grouped and highly finished. Another work of this kind is photographed in (212), viz. Mr. Phyffers' alto-relievo in alabaster, representing the "Sacrifice of Abraham," to be placed in a new church at Limerick. Mr. Phyffers has another contribution (324) of a different kind,—"Doors carved in wainscot for the Marquis of Northampton, from the designs of Mr. Digby Wyatt."

In (196) we have a very handsome design, by Mr. Bentley, for a "Proposed clock tower and drinking-fountain," which forms altogether one of the most striking pictures in the exhibition. Its fault is, undoubtedly, a too luxuriant fancifulness, but the general conception and the details are, throughout, in the best taste: they all partake more or less of *château* elements picturesquely combined. "Brenkbourn Priory," well known as an interesting Northumbrian ruin, is restored in imagination by Mr. F. R. Wilson, whose drawing (197) reproduces the interior view. Where so much has to be supplied, the fancy must range according to the taste of the designer; suffice it therefore to say that nothing we here see appears beyond the range of probability, or inconsistent with the early period of architecture to which the building dates; polychrome is freely introduced. (198) is a drawing *per se*, and as such occupies a prominent position in the gallery. It displays a restoration, full size, of the "Centre panel of the ancient retabulum of the high altar at Westminster Abbey,"—a most sumptuous array of conventional ornament in painting, gilding, and mosaics, which have here been copied with the utmost exactitude. The variety and beauty of the small geometrical patterns add greatly to the superb effect of the whole. The large figure here shown in the centre panel belongs in reality to one of the side ones, the proper figure, which represents Our Lord, not having been copied in time for the exhibition. Immediately below this frame is (199) a delicate and beautiful oil painting by Mr. Allom, being a view of the "Ancient church of St. John at Pergamos, in Asia Minor,"—one of a series of delineations of the seven primitive churches,—which has more attractions as a landscape scene than on architectural grounds. (200) A collection of "Old architectural drawings," by Neümann, Cotman, and Coney, here exhibited by Mr. Harry Oliver, will be examined with much interest. They are eleven in number, and mostly from continental sources. The free artistic style of Mr. Cotman, so observable in his etchings, will be here again recognised.

"The ruins of Arbroath Cathedral" are feebly shown in Mr. Beetholme's drawing (202), the only one exhibited this year by him. The anastatic prints which follow (203-208) are a series of small sketches of churches and schools by Mr. R. J. Withers, simple subjects in themselves, and consistently treated throughout. (210, 211) Are not very clear photographs from a design by Messrs. Green and De Ville for a grand Opera-house at Rio de Janeiro, and which received a premium of £900. It is shown both internally and externally, and presents a handsome but not strikingly original building in the Palladian style. It may be presumed that colour plays an important part in the design, but this, of course, is in the photographs entirely lost.

Mr. Habershon's "Lodges at Bedwell Park" (215—219) are very commonplace, set off to advantage by the way they are here grouped, and by the handsome frame in which they are set. It is not difficult to distinguish Mr. Street's drawings from those which are done in imitation of his peculiar style. As usual, those he exhibits are in pen-and-ink, artistic and expressive in the highest degree; though perhaps, if any objection is raised, it would be to their somewhat artificial effect as compared with the buildings themselves. In (220) he shows, in a masterly bird's-eye view, the church, parsonage, and schools at Boyn Hill, a work which has now been completed several years, with the exception of the steeple, which is here supplied. It is scarcely needful to enlarge upon the beauty of these designs, or the picturesque way in which the different buildings are collocated;—they may safely be classed among the earliest and best compositions in which brickwork, plain and ornamental, has been used as the staple material. (221, 223) Are respectively the interior and exterior of the new church now in progress at St. Giles', Oxford,—abounding in originality and skilful applications; while the portions of the recently erected "Grammar school and vicarage house at Bloxham," sketched in (222), are, though plain, if possible, more genuine and successful still.

Mr. S. J. Nicholl exhibits two drawings in connection with the R.C. Cemetery at Kensall Green; (224) being the "Chapel" (a view of which has lately appeared in our Journal), and (325) the "Lodge," which is chiefly noticeable for the clever detail of its windows. (225) By Mr. W. Purdue, is a choice specimen of ancient ecclesiastical decoration (mural), very carefully drawn, and depicted in colours. The subject is "Two compartments from the church of Sta. Maria dell'Annunciata, Padua." Mr. F. R. Wilson has in (226) several drawings of his executed works, of precisely the kind which are suited to an architectural exhibition, if we take a slight exception to the prevailing colour of the tinting, which is too sombre and uninviting. The same fault deprives Mr. Wilson's three other elaborate pictures (227-8-9) of much of their real value. In the first and third of these is

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shown the "Forum Romanum at Rome," one view looking towards the Capitol, and the other towards the Colosseum, and displaying that noble scene restored to its ancient magnificence. The second presents a gorgeous array of Mediæval English buildings, consisting of ancient cathedrals, churches, and domestic buildings, forming a well-arranged cluster, and beautifully outlined,—much more carefully indeed than the Classic groups. These pictures, which are unusually large, are intended in some degree to help in deciding the "battle of the styles," now being so fiercely contested; and they are intitled respectively, "Is it to be Classic?" "Or is it to be English?" Alnwick Castle, shown in various views by Mr. Wilson's remaining pictures (230-1) is well known as one of our grandest ancient remains, proudly situated on a commanding height. The building has been recently enlarged; externally Mediævalised, and internally Italianised, both with the utmost care and at a lavish expense;—but does not this curious fact offer rather ambiguous evidence on the question just raised?

Messrs. Maw and Co. are deserving of praise for the pains they are taking in perfecting and ornamenting the material which is identified with their name, and for calling in the professional aid of such men as Mr. Digby Wyatt for the purpose. Still we cannot altogether endorse their designs for the application of mosaic to roofing, as shown in (232, 233). The idea is a good one, but the method of working out requires maturer study, in our opinion, to produce a thoroughly satisfactory result. In (234—238) Mr. W. Mumford shows a number of small drawings, principally of domestic buildings. Of these the "Station villa at Twickenham" appears much the best.

A thoroughly architectural drawing is (240) "The south porch at St. Alban's Abbey," by Mr. Edis, who in the most careful manner has delineated this pure specimen of early Gothic work, by means of plan, section, and elevation to an appreciable scale. It would be an exception to find a picture exhibition in which Westminster Abbey is not in some way or other introduced. The two peeps which Mr. Richardson has selected (241, 242), though they have been given dozens of times before, have lost none of their attractions; we are bound, however, to say that our artist has not here done them justice; and that the detail of the ironwork to Queen Eleanor's tomb is absolutely incorrect.

No one can either overlook or mistake Mr. Truefitt's productions, of which year by year he is in the habit of contributing his quota. Those which are collected in one frame and numbered (243—253) consist entirely of schools and dwelling-houses of more or less pretension, except a little Worcestershire church, and the shop (lately altered) at the corner of Bond-street and Burlington-gardens. Mr. Truefitt adheres to his favourite materials, light brick with red bands, sparingly relieved by stone dressings and carving, and liberally besprinkled with ironwork in various forms. All these are *legitimately* employed, thus imparting an air of common sense utility to well-studied arrangements; and this is the chief secret of Mr. Truefitt's success in design, notwithstanding his occasional eccentricities.

Mr. Wallen's "South-west view of Mayence Cathedral" (256) is careful and effective. Mr. Roger Smith's "Mansion now erecting at Stratton Audley-park," is shown in two drawings (256, 257); the latter formed the subject of one of our illustrations last month, and was then described. It is therefore needless to refer to this subject again, except to say that the other drawing shows the design in quite as favourable a light as the one we have given. In quite another line of art is Mr. Sedding's "Design for reredos, embroidered frontal, and altar furniture, for the use of the English (?) church" (259, 260):—very good in its way, and cleverly drawn. The Palazzo Bartholini at Florence, the first in which a pediment was employed to the doors and windows, and the Pandolfini Palace, in the same city, attributed to Raphael, form the subjects of two slight and rather feeble pencil perspectives by Mr. Hebb (261, 262). The pediments to the windows are alternately pointed and curved.

Decidedly one of the best and most vigorous designs in the exhibition is that by Mr. Norman Shaw, for a priest's house to be erected in Belgium (263), of which the great merit is unusual originality interpreted by the simplest means. Where enrichment is added, it is in the best possible taste. The style, it need scarcely be remarked, is Gothic. Equal versatility in another direction is manifested by Mr. E. B. Lamb's various works (264—267). In all these the author displays his appreciation of the picturesque by the novel and ingenious groupings of parts which he invariably secures. In this he is more successful than in minor details, which he is apt to exaggerate, while his would-be pure Gothic designs, for churches especially, as (271, 272), are far short of the true standard. In (270) we again meet with Mr. Norman Shaw, who gives two "Monuments about to be erected in the cemetery at Bruges,"—neither, as it seems to us, worthy of his reputation, though not devoid of originality. The parts are very disproportionate, and this defect the very clever design of the ironwork cannot redeem.

As a pencil drawing perhaps there is none superior to Mr. Nesfield's "Tympanum from the north doorway at Chartres" (273), every portion of which bears evidence of extreme accuracy, and is clearly rendered. The quaint grotesqueness of the sculpture is particularly observable. Another painstaking draughtsman is Mr. Lockyer, who shows in (275) several examples of the application of mosaic, "From a room in Palazzo Reale, Palermo" (12th century), and from marble pulpits at Ravello. See also (277). These are mostly expressed in pen-and-ink, and are minutely copied. (276), by the same architect, is a mural monument, treated in a simple but very effective manner. The material is Sicilian marble, upon which an ornament is first incised and then filled up with a black composition, in the manner of the inlaid "dallage" and slab tombs of Italy and France during the 13th, 14th, and 15th centuries; and the practice of which is now being revived. To the outline of the monument itself we are rather disposed to demur. Mr. G. R. Clarke has been decidedly successful in his "New gable and shop-front, Coln St. Aldwyn," an Elizabethan-looking, mullion-and-transomed addition, projecting forward on the ground-floor only, after the manner of a bay window, and having a hipped-tile roof, well contrived. Casting our eyes for a moment upon a supposed Classic design for the Wedgewood Institute, Burslem (288), which is conspicuous by its ugliness, we arrive at a pretty "Swiss chalet" for the Earl of Yarborough (290), constructed (portably the catalogue tells us) by Messrs. Arrowsmith. The colouring of the different portions, as here indicated, promises well for the effect. An exterior and interior view of two Roman Catholic churches at Northampton and Cork (291, 292), by Mr. E. W. Pugin, possess, like several other of his works of which photographs are shown in (320, 321), a considerable amount of talent and originality. There is however a tendency in some to over-slenderness.

The "Additions to Apley Castle, Salop" (293), by Mr. Habershon, are to be Palladian, of consistent character throughout, and well balanced. Neither of the latter distinctions can be accorded to Mr. Sancton Wood's "House at Kilcroney" (294)—a miserable attempt at Gothic. Of several "Designs for drinking-fountains" submitted by Mr. F. P. Cockerell (297, 300, 301), that erected at Spilsbury is by far the most pleasing and novel. The cleverness of the drawings themselves is worthy of note. A "Conservatory in course of erection at Stanmore Hall" (298), from the designs of the same gentleman, is lightly treated, as regards materials, and delicately ornamented. The frame (305) filled with drawings of "Northamptonshire steeples," by Mr. Slater, shows admirably in contrast the prevailing features of the local architecture—rich and varied, as is well known. The "Interior view of St. George, Bassaterre, St. Kitts," erected from designs by the same gentleman, is a large drawing of a by no means extraordinary building: it is cleverly drawn in brown ink, and slightly washed with sepia. There is a small plan at the foot, which shows, we perceive, one or two unusual arrangements. (310) Is a particularly successful architectural work, at least as far as design goes; it is a "Carriage manufactory at Bristol," and its author Mr. E. W. Godwin. The bold and simple arches on the lower story are well proportioned, and suited to display to advantage the articles within, and they are skillfully adjusted so as to contribute in no small degree to the imposing effect of the façade, which in the upper stories is also treated in a masterly way. The materials mentioned in the catalogue as *proposed* to be used were Bath stone, the blue Hannam stone, and the Bristol red. The red stone and all the carving, and a great portion of the solid freestone, were omitted in carrying out the work, thus no doubt greatly deteriorating the effect.

The Hon. Sec. to the Exhibition, Mr. Edmeston, contributes in (312) two "Stone doorways from houses now erecting at Norwood." They are both simply treated as regards the designs, but what might appear wanting as ornament is more than compensated for by the thoroughly artistic feeling evinced, and the good proportions of the several parts. Mr. Edmeston has on previous occa-

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sions exhibited detailed portions of his executed works, to which these are a welcome addition.

Over the door are some stained glass cartoons (314), by Lavers and Barraud; one being part of a window from Waltham Abbey (which was reopened a few weeks since, after its partial restoration by Mr. Burges); and the other, the centre light of the east window for Bridport Church, a cartoon by Mr. Barraud. Both these, as well as (354), by the same artists, are a decided step in advance of the commonplace productions we too often see. In the last mentioned—a competition design for a window in Canterbury Cathedral—the subjects are numerous, and for the most part included in squares, the arrangement of which is somewhat novel. We miss this year the names of other artists in stained glass who have been wont to exhibit, and we regret the fact.

We cannot speak altogether commendingly of Mr. E. Richardson's "Mural Memorial," erected in 1859 in Winchester Cathedral, and of which a photograph is given in (316). It is Gothic, and apparently intended for "Decorated," for which some of the carving might pass; but the principal enrichment has unquestionably much more of "Perpendicular" character about it, and besides, is not happily composed. The "Saloon carriage" constructed for the Viceroy of Egypt, and a Locomotive engine and tender, are shown in (317, 318, 319), principally, we presume, on account of the decorations, in black, white, and gold, which have been freely added by Mr. F. G. Crace, from the designs of Mr. Digby Wyatt. Of these it is not too much to say that they are extremely chaste and elegant, and their application to such a purpose surely marks a new era in art.

(322) Mr. J. Drayton Wyatt's view of the central "Octagon" of Ely Cathedral, proposed to be restored under the superintendence of Mr. Scott, as a memorial to the late Dean, shows a picturesque bit of architectural grouping such as is seldom seen. The restorations and additions contemplated are all founded on a minute survey of existing remains, and, when reinstated, will add vastly to the appearance of the celebrated lantern, now shorn of so much of its beautiful detail. Mr. Drayton Wyatt exhibits also, in (340), an "Interior of the New Church at Haley Hill, Halifax,—one of the handsomest and most complete of modern edifices. The Architectural Association sends, as heretofore, a large collection of "Sketches by the Class of Design" (323). These do not appear to be, as a whole, equal in interest to many we can remember; perhaps Mr. Lloyd's "Ornamental brick cornice" (20) is the best, and Mr. Ough's "Organ case" (4) the worst; as Mr. Roger's "Chimney stack" (13) is assuredly the most *outré*. Mr. Haddon's "Toll-house" (30) may be mentioned for its ingenuity There are altogether thirty-one sketches.

Of the few designs in Metal-work we meet with in the Exhibition, one of the most perfect is (329) a photograph of a silver chalice, designed by Mr. Street, and executed in parcel-gilt, jewels, enamel, and filagree. The latter work on the upper part of the foot is exquisitely rendered. Some small photographs of Mr. W. J. Green's "Design for the Governor-General of Canada's official residence at Ottawa" (330) (which were the second premiated design), and also of Mr. Scott's "New Government Offices, London" (331—335), are scarcely on a scale sufficient to give more than a notion of general effect. The American building is rusticated Italian, and appears to be rather plain. Though perhaps Mr. Ernest George may be charged with copyism in some parts of his "Design for a grand hotel," to which the Royal Academy gold medal was awarded last year, and of which a photograph is given in (341), it is nevertheless far above the average. It is moreover Gothic, and well detailed. The building is supposed to be surrounded by streets, and to have shops on the ground-floor, also a glass-covered central court. Mr. Hayward's "Oak cabinet" —see photographs (342, 343)—is a gem in its way, especially in the matter of the carved ornament, in which the designer appears to have been more successful than in the main outlines. Mr. H. J. Coombs' "Design for altering Blackfriars-bridge" (343 A), suggests the removal of the three centre arches (which includes the two now defective ones), and the substitution of a single iron one of 280 feet span, supported on piers built to receive it. As an architectural expedient the idea promises no improvement, and this scheme especially, as it would seem by its details to engraft some strange pseudo-Gothic elements. Though Mr. Goodchild's large and beautiful drawings of the "Interior of St. Paul's Cathedral, according to Wren's first design," were among the leading attractions of this Exhibition last year, we are glad now to welcome the photographs (337, 338), which are sufficiently large to give a true impression of the several parts and of the effect of the whole. Mr. Robins' "Design for the Exeter branch of the Devon and Cornwall Bank" (347), to which the first premium was awarded, is a good Classic composition, showing a rusticated ground-floor, with narrow slightly projecting wings, terminated at the principal cornice by circular pediments. Mr. Robins' design for the "Tabernacle" (348) was shown on the table last year.

The Architectural Publication Society is represented by a selection of lithographs from the illustrations to their 'Dictionary of Architecture,' now in course of issue, but which does not appear to make very rapid progress. (350), Mr. Corson's "Designs for offices for guardians and overseers of the township of Leeds," is Gothic, in which he is less happy than in his more Italian designs; while Mr. Phipps' "Competition design for the Lyncombe Cemetery, Bath" (also Gothic), is much too fussy. The "Pimlico Rooms and Literary Institution" (353), by Mr. J. W. Penfold, is an unpretending but well arranged Italian design; and Mr. E. I'Anson's five "Sketches in Lubeck" (352) are exceedingly useful and suggestive: they are slightly washed over with colour, just sufficient to render the details clear, without attempting anything artistic.

On one of the screens are four frames containing a series of lithographs, which our readers will recognise as selected from the recent illustrations in this Journal: there are also several specimens of coloured decoration, by M. Aguami, peculiarly rich and telling. One of these is for a pier or pilaster, and is painted on glass, and silvered. On the table also is a large number of photographs from Messrs. Evans and Pullen's "Design for Lille Cathedral," which we described at the time; with a portfolio of Mr. Pullan's "Design for Constantinople Church," also photographs, and which obtained special mention. With these concludes our survey of the present exhibition, which will remain open until the end of the month; to re-open next year as usual. Meanwhile the rooms will devoted to a continuance of the exhibition of practical works, materials, and inventions connected with architecture, which has hitherto been productive of so much benefit, and for which we desire increasing prosperity.

NEW CHURCH OF ST. JOHN, NEWPORT, MONMOUTHSHIRE.

(With an Engraving.)

The church of St. John the Evangelist has been recently erected in the parish of Christchurch, and district of Maindee, a rapidly increasing suburb of the town of Newport, and in the diocese of Llandaff. The edifice consists of a nave and south aisle, with a tower over the westernmost bay of the same. The aisle is divided from the nave by an arcade of four bays (including that of the tower), and it is continued eastward, so as to form a chancel aisle of one bay. There are western and southern porches, roofed with laminated slabs of stone on moulded ribs. The view given in our illustration is taken from the south-west, where is the principal approach. The church is situated upon the slope of Maindee Hill, which is being rapidly covered with villas, and which forms a pleasant suburb to Newport, commanding as it does fine views of the Bristol Channel and the scenery around.

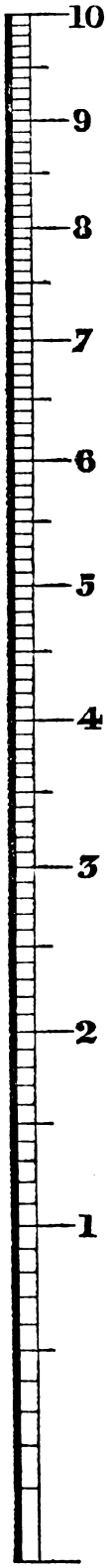
The structure is substantially built of thin Pennant sandstone, with Combe-Down Bath stone dressings, and is relieved by bands and voussoirs of blue limestone. The timber generally is Memel, but all the furniture is of pitch pine. The roofs are covered with small Delabole slates, and are also boarded and felted beneath. The windows are large, and richly traceried with geometrical tracery. The chancel arch is decorated with carvings of the vine and wheat; and the capitals of the nave columns are also carved, each with a different type of natural foliage conventionally treated. The church contains accommodation for 500 persons; and the cost has been about £3000; the tower at present being carried up only above the ridge of the roof. The spire when complete will be 180 feet high. The whole is from the designs and has been carried out under the superintendence of the diocesan architects, Messrs. Prichard and Seddon, Whitehall, London. The contractor, who has excellently performed his part, was Mr. Logan; and Mr. Biggs the foreman superintending the work. The carving was executed by Mr. Earp, of London.

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MEASURING WATER BY WEIRS.*

By JOHN SANG, Kirkcaldy.

IN measuring the quantity of water flowing in streams, the preferable method, and that generally employed where practicable, is to make a dam across the stream, and cause the water to flow through a rectangular notch. The quantity of water passing varies with its height and the breadth of the notch,—with its height in a proportion depending on the square root of the cube, but with the breadth in a simple proportion. There are tables for the solution of the question, one of which is appended to this communication; but I have found great convenience in having the scale (as in figure) divided on the edge of the foot-rule, giving at once the number of cubic feet per minute of water to every inch in breadth of the rectangular notch. By this means nothing more is required than to observe at what number the water stands on the rule, and to multiply that by the number of inches in breadth of the notch or weir; and as it may be convenient for other engineers, I have much pleasure in laying before the society the accompanying scale, divided on paper, together with a table showing the sizes of the divisions of the scale, so that it may be readily copied on a rule.



A scale of this sort may occasionally be useful as a permanent gauge of the quantity of water in a stream; and I have found, in a case in which two parties were interested in a stream, that by causing such a scale, modified so that the divisions corresponded with the breadth of the weir through which the water flowed, to be divided on paper, hermetically sealed within a glass tube, and fixed up in the water, a very satisfactory gauge was obtained, little liable to go out of repair, and from which either party could see at a glance how many gallons or cubic feet of water were flowing past per minute.

The formula from which the divisions of the scale are calculated is $H=(54{\cdot}5D)^{\frac{2}{3}}$, H being the distance of the division from the beginning of the scale in inches, and D the discharge in cubic feet per minute. The formula is derived from the usual one of $D={\cdot}428H^{\frac{3}{2}}$, so that, in using the scale represented in figure, all the ordinary conditions in the form of the edge of the weir, and other particulars well known to engineers, have to be attended to. The divisions are figured from the bottom upwards at each ten; the figures are the number of cubic feet per minute for each inch of the weir. Thus, if the water stand at 2·6, and the weir be ten inches broad, there are twenty-six cubic feet of water passing per minute.

Division.	Distance from the zero.	Division.	Distance from the zero.	Division.	Distance from the zero.
	Inch.		Inch.		Inch.
·0	·000	1·8	2·604	3·6	4·134
·1	·379	1·9	2·700	3·7	4·210
·2	·602	2·0	2·794	3·8	4·285
·3	·789	2·1	2·886	3·9	4·360
·4	·955	2·2	2·977	4·0	4·434
·5	1·109	2·3	3·066	4·1	4·508
·6	1·252	2·4	3·155	4·2	4·581
·7	1·387	2·5	3·242	4·3	4·654
·8	1·516	2·6	3·327	4·4	4·726
·9	1·641	2·7	3·412	4·5	4·797
1·0	1·760	2·8	3·496	4·6	4·868
1·1	1·875	2·9	3·579	4·7	4·938
1·2	1·987	3·0	3·661	4·8	5·007
1·3	2·096	3·1	3·741	4·9	5·077
1·4	2·202	3·2	3·822	5·0	5·146
1·5	2·306	3·3	3·901	5·1	5·214
1·6	2·407	3·4	3·979	5·2	5·282
1·7	2·507	3·5	4·057	5·3	5·350
5·4	5·417	7·0	6·440	8·6	7·387
5·5	5·483	7·1	6·501	8·7	7·444
5·6	5·549	7·2	6·562	8·8	7·501
5·7	5·615	7·3	6·622	8·9	7·558
5·8	5·681	7·4	6·683	9·0	7·614
5·9	5·746	7·5	6·743	9·1	7·671
6·0	5·811	7·6	6·803	9·2	7·727
6·1	5·875	7·7	6·862	9·3	7·783
6·2	5·939	7·8	6·921	9·4	7·838
6·3	6·003	7·9	6·980	9·5	7·894
6·4	6·066	8·0	7·039	9·6	7·949
6·5	6·129	8·1	7·098	9·7	8·004
6·6	6·192	8·2	7·156	9·8	8·059
6·7	6·254	8·3	7·214	9·9	8·114
6·8	6·316	8·4	7·272	10·0	8·168
6·9	6·378	8·5	7·329		

* Paper read at the Royal Scottish Society of Arts.

THE SCULPTURE OF THE ANCIENTS.*

By JOHN NORTON, F.I.B.A.

I will not attempt to elucidate the much controverted questions referring to the origin and the exact date of the origin of sculpture as a fine art—but I think the more we inquire the more fully satisfied shall we be that its origin dates beyond all written records, and that the Greeks were quite moderns in the art, compared with the nations who practised it in the ages which preceded them. Instead of Dædalus introducing the art into Greece, it is pretty clear he was simply an improver on what had gone before. No doubt, by adding life to the expression of the features and animation to the limbs of his statues, he made a great advance on his predecessors, but although the ancient writers speak of his works as possessed of divine expression, we may rest satisfied that, though good for some fourteen centuries before our era, they could not compare with the works of later schools. His was, no doubt, a great epoch in the history of ancient sculpture, but as all the examples of that and other cotemporary schools have perished, we have unfortunately no means of comparing the relative excellence of each in their various phases. Rome became the great art treasure-house of the civilised world from the spoils of Greece and Etruria, but she was robbed of her accumulated spoils by Byzantium, who in turn was despoiled of her treasures, which were irrecoverably lost in the various sacks and conflagrations to which she was subjected; aided too by the zeal of Constantine in destroying all traces of the ancient worship, not however, in either case, before accomplishing their mission of perpetuating the art and founding separate schools, the influence of which was felt throughout the middle ages.

It will be instructive to advert to the various materials and modes of working adopted at each period by the ancients. In the most ancient times it is probable that the impressions of form were presented to the eye by the softer and more plastic materials; and that the modeller in clay, at first a potter, modelling objects for his art, at length became so adept, that he ventured upon reliefs, and eventually figures. We see in the Greek and Etruscan pottery what exquisite forms of art the material was susceptible of, and it seems very natural that a high development of this art should lead to subsequent excellence in works in various stages of relief.

Numerous proofs of the excellence of the potter's art are to be seen in the terra-cottas in our own and foreign museums; at Rome, statues of the gods larger than life, and at Naples, life-size models recumbent on Etruscan sarcophagi, show how nearly the art approached that of sculpture. Alabaster or gypsum was much used by nations even more ancient than the Greeks. Relief in stucco was the art of forming practised by the Romans.

It may be noted that the ancient terra-cottas and figures in pottery are for the most part highly coloured, from which was probably derived the custom, which at all events was partially practised by the ancients, of colouring statues worked in marble and other hard materials. Great dexterity was shown in the formation of figures in bronze and brass, sometimes by casting and soldering in the locks of hair and other projecting details; at

* Abstract of a paper read at the Architectural Association.

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other times, by hammering and embossing for works in gold and silver.* Brass figures were frequently covered with gilding, remains of which can now be seen on the celebrated horses at Venice. The ancients do not seem to have understood the tempering of iron, so as to use it for art purposes. Carved figures in wood were used both in the temples and for private objects, the favourite wood being cedar, which had the reputation of being incorruptible. Ebony, citron, cypress, vine, olive, and other woods were also used. But the substance most prized by the ancients was undoubtedly the *mannor* or marble, from its shining and polished surface. The marble from Paros was most prized by the Greeks, but in later times coloured marbles were much used. Other kinds of marble in great repute were Canara, which resembled fine sugar; Penthelic, which was veined and streaky; and Hymettian, the Nero-Antico, a favourite marble for statues of Isis; Rosso-Antico, and porphyry. Calcareous tufa was also used, especially for Etruscan sarcophagi.

The Egyptians showed marvellous dexterity in working the harder materials, such as porphyry, granite, basalt, and syenite. The Romans worked occasionally in these harder materials, frequently inlaying portions with various coloured marbles, and even with metals; busts and figures executed in this manner do not accord with our modern notions of refinement, and have a disagreeable harsh appearance, but the practice among the ancients seems to prove their love of colour, and it is natural to suppose that this polylithic process of sculpture originated from the use in the antique examples of actual painting and gilding, originally with vivid colours, and afterwards with softer tones; this is called polychromic sculpture. I think, in comparison of the two processes, the latter would be more in accordance with refined taste. Another favourite practice was coating the surface of the marble with wax, which gave the surface a soft and slightly coloured gloss. The draperies, the hair, and portions of ornament were also painted, but apparently only for the purpose of relief, for I do not consider the practice of entirely covering the surface of sculpture with bright positive colours as anything short of a libel on the tastes of the ancients. In modern times Canova and Gibson have adopted the same method of rubbing the surfaces of marble with wax and of partial polychrome, as far as I have had opportunities of judging, with perfect success.

The last process to which I shall refer to is that of carving in ivory. When the art of the Toreutes, or metal-workers, was combined in ancient times with carving in ivory, we come to a process which is called "chryselephantine" sculpture, which was much practised in antiquity, and is undoubtedly the most important development of carving in ivory. The ancients procured elephants' teeth from India and Africa of great size, and by a process of splitting and bending, we are assured that they could obtain plates of ivory from 12 to 20 inches in breadth. The colossal figures executed in this manner appear to have been covered with these plates of ivory, joined with isinglass, over a rough internal model made of wood, and iron bars for support. Pausanius mentions that the teeth of the hippopotamus was also used instead of ivory, and the northern nations of Europe are known to have used the tusks of the walrus, from which drinking horns of immense size were made, the surfaces being sculptured with hunting and other scenes. The most celebrated examples of the "chryselephantine" method were the colossal statue of Minerva, in the Parthenon, by Phidias, which was about 39 feet in height, and an equally celebrated statue of Jupiter, in his temple at Olympia. The cost of such works is described to have been fabulous, and it is clear that the labour and expense of execution must have precluded their frequent repetition. We thus find that ivory came at length to be used solely for objects of cabinet size, such as diptyches, triptyches, situlæ, devotional tablets, statuettes, and generally to mobiliary works. It is supposed that the ancients had a method of softening the ivory, which would render the process of elaborate carving and occasional undercutting less remarkable, but this has been doubted by some authors.

As illustrations I will describe various examples from the Greek period, through the Roman, Byzantine, and Mediæval, down to the time of the Renaissance. The Arundel collection will furnish examples of almost every century from the second to the sixteenth, whilst the photographs taken from original works at Rome, Florence, and elsewhere, will illustrate the works of Greece and Rome. The works of d'Agincourt will be of great assistance in filling up gaps and affording additional illustrations.

Jewish.—Of the ancient nations whose art had a separate existence to that of Greece and Rome I have no illustrations to offer, but we need go no further than the Bible to prove that the art of sculpture had reached great perfection amongst the Phœnicians, Tyrians, and others. We read too of gilded images of gods existing at Babylon, carved in gold, in silver, and in wood; and the ample description of the building of the Temple of Solomon by the Jews, containing incidental art references, seems to show that at that period (1000 years before the Christian era) the sculptor's art was not then in its infancy.

Egyptian.—Of Egyptian sculpture we have numerous and fine examples in our own Museum, and in these we trace an intimate connection between the architectural and sculptural arts, and even with the literature of the nation, in the symbolic forms, images of men and beasts, but more especially in the hieroglyphic enrichments with which the surfaces of the architectural members are elaborately covered. In their sculptured figures, besides the colossal grandeur of their size, there is a dignified composure which seems never broken, and it is impossible for us to contemplate them without a feeling of awe, ignorant though we be of their symbolic and mystic meaning. This applies even more remarkably to the animal than to the human forms, for we know that particular animals were held in the highest esteem by the Egyptians. There is however great conventionalism and want of variety, as well as an absence of life, tending to prove that their artists were compelled to obey rigidly certain types and established proportions, which precluded originality, and that the study of anatomy was restricted by law. This is especially observable in their temple sculptures, but when warlike and domestic scenes are attempted there is an air of greater originality. Their reliefs generally rise very slightly from a sunk or depressed surface. The marvellous head of the so-called Young Memnon is perhaps the finest example we have, and although it has the usual characteristic thick lips, projecting eyes, and rounded nose, it still possesses great dignity and beauty.

Etruscan.—The art of this nation is preserved to us more particularly in the cinerary urns of their tombs; both these and their sculptures have a close resemblance to the early and stiff character of the Greek school, particularly that of Ægina. Their sculptures were usually in terra-cotta, sometimes of stone and bronze, and show signs of having been painted; remains are also found in the tombs, proving their excellence in working the more valuable metals. The heads frequently possess great beauty, but the draperies and actions of the figures are far inferior to the best works of Greece, the attitudes being exaggerated, and the drawing generally affected and unnatural, but possessing at the same time masculine power, and though stiff, still a bold independent treatment, which distinguishes the school of Etruria from that of Greece; in lieu of the grace of the latter we find violent muscular, almost contorted action, combined with much delicacy of execution.

Greek.—The archaic was the most ancient period of Greek sculpture. I will illustrate it with the example of the temple of Jupiter Olympus at Agrigentum, which has been so well illustrated by Prof. Cockerell. The Atlantes which support the entablature, and attached to the walls of the cella of this temple, form an interesting example of the archaic manner of the Greeks, and are not unlike the works of Etruscan sculptors. The manner in which they subserve the architectural forms is very interesting, and their bold, angular, and energetic treatment seems to suit them admirably for the object in view, which was to support a superincumbent weight. Their height was twenty-five feet, and they were constructed with stones having parallel courses with the walls of the cella, and the joints of the alternate courses show vertical joints, and thus form a part of the construction of the cella. You will notice the peculiar character of the heads, with the half-closed eyes, long and prominent nose, and hair arranged in uniform curls. Although these sculptures are supposed to be only about four centuries B.C., consequently not anterior to the Parthenon sculptures, still we see in them a much earlier treatment, proving that the ancient manner was practised later in Sicily than in Greece. The next great period was that of Phidias, when the art made a wonderful advance, and during which the grandest works the world ever saw were executed. The early stiff forms were rejected, and the rigid and inelegant actions of the archaic period became refined, and instead of the dryness and hardness of their treatment, we find in the works of Phidias the most perfect expression of the human form,—graceful and flowing lines taking the place of the severe and architectural forms of the early period. The casts exhibited of the Theseus and Ilyssus from the Parthenon, afford

* This process was termed Toreutic art, and was employed for shields and armour.

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perhaps the most perfect example of this style, the originals of which are to be seen in our own Museum. The first has lost portions of the legs, arms, and nose; the size of the original is 5 ft. 8 in. by 4 feet in height, and has been called by other authors Hercules; the figure is half-reclined upon a rock, covered with drapery and the lion's skin. The wonderful development of the anatomy is to be remarked, and thus is combined the most perfect scientific knowledge and truthfulness to nature, with the highest ideal of beauty. The Ilyssus is a figure equally beautiful, from the opposite or western pediment of the Parthenon; it is half-reclined like the Theseus, to suit the raking lines of the pediment: the figure possesses great truthfulness and animation.

The next great period of development was during the age of Praxiteles, who introduced a more sensuous style; and Greek sculpture lost much of its sublime character, but exhibited the utmost technical skill in drawing, especially of figures in the nude. Some of the finest works of this period are the Pythian Apollo, which was found in the fifteenth century near the ruins of the villa of Nero, at Antium; the Venus of the Capitol, found in the eleventh century; and the exquisitely refined statue of the same goddess in the Tribune at Florence, which is probably of the age last mentioned, and is an instance of the departure from the rigid grandeur of the earlier forms, and displaying the most fascinating and graceful harmony of lines and purity of expression. The Dancing Faun is another marvellous specimen of Greek art at its perfection, differing from the last instance in its muscular development and elasticity of movement; the entire figure seems in action, but there is nothing unnatural or distorted, and the physical quality seems subordinated to that of ideal refinement. A beautiful example of the best period, illustrating the peculiar mode of draping the female figure, is shown in the statue of Pudicitia or "Modesty," from the Vatican; this figure possesses wonderful grace and dignity, and the folds of the drapery are arranged in broad masses, and have the appearance of being modelled from drapery wetted and applied closely to the body, showing the form beneath. Another photograph shows that marvellous example of refinement and dexterity of execution, the group of Laocoon, found in the ruins of the Baths of Titus. Technical difficulties of execution have evidently been sought for, and it is impossible to imagine anything more perfect than the drawing and anatomical perfections of this work, at the same time the sentiment of the subject is so well preserved, that the spectator is agonised at the sufferings of the father and his sons. This perfect work of ancient art throws into the shade the performances of Michael Angelo, which appear stiff and cold in comparison.

Roman.—From the decline of Greece, Rome became the great cultivator of the art, and as the Grecian sculptures found an asylum at Rome, and as the chief works were transferred from Greece as the spoils of war, it is natural that the early works of the Roman schools take a Grecian character, and supplanted the earlier style, which was founded upon the Etruscan; and sculpture became much more generalised in its adaptations; equestrian statues, and public works of every kind, gratified their taste for splendour. The base of the column of Antoniue, representing the Apotheosis of Antoninus and Faustina, is an illustration of their sculpture, in which we trace much of the Greek feeling; whilst the marvellous sculptures in the column of Trajan show an entirely new application of the art, and illustrate the fertility of their invention; but the art became gradually debased, and it degenerated into luxurious and capricious forms. The busts and portrait statues of the emperors form an important class of this time, and we have numerous illustrations of historical events. Many works were executed in the time of the Antonines, but afterwards became gradually debased, an illustration of which may be seen in the sculptures on the arch of Constantine, which are executed in a rude and clumsy style, and we finally lose all traces of distinctive Roman art in the works of the Byzantine sculptors. In many of the earlier Christian monuments traces are to be found of the Roman manner in the catacombs and sarcophagi of the first ages of Christianity. I draw your attention especially to the sarcophagi of Bassus and of Probus, both executed in the fourth century, and in which the reliefs containing Old Testament subjects might be taken for debased Roman work.

The author then exhibited and described a large number of copies of ancient sculptures in ivory, photographs and engravings, from the collection of the Arundel Society, illustrating the subsequent development of sculpture throughout the early periods of the Christian era.

ON THE THEORY OF RAIN.*

By Joseph Baxendell, F.R.A.S.

It has been well established by numerous carefully conducted experiments, that the quantity of rain received by a gauge placed on or near the ground is almost invariably greater than that received by a similar gauge placed at a greater elevation in the immediate neighbourhood; and in explanation of this remarkable fact meteorological writers have generally adopted the hypothesis advanced by Prof. Phillips ('Report of the British Association for 1833,' p. 410), "that the whole difference in the quantity of rain at different heights above the surface of the neighbouring ground is caused by the continual augmentation of each drop of rain from the commencement to the end of its descent, as it traverses successively the humid strata of air, at a temperature so much lower than that of the surrounding medium as to cause the deposition of moisture upon its surface." In support of this hypothesis, Prof. Phillips remarks "that it takes account of the length of descent, because in passing through more air more moisture would be gathered; it agrees with the fact that the augmentation for given lengths of descent is greatest in the most humid seasons of the year; it accounts to us for the greater absolute size of rain-drops in the hottest months and near the ground, as compared with those in the winter and on mountains; finally, it is almost an inevitable consequence from what is known of the gradation of temperature in the atmosphere, that some effect of this kind must necessarily take place."

Now, although it must be admitted that the temperature of falling rain is generally below that of the air near the ground, yet if we proceed to determine the temperature of a rain-drop at the commencement of its descent, from its known rate of augmentation in falling, and from its temperature when it arrives at the surface of the ground, we shall obtain a result wholly inconsistent with known facts, and therefore fatal to the hypothesis.

The most complete series of observations with which I am acquainted of the quantities of rain falling at different heights, is that made at York, in the years 1832-5, by Mr. Gray and Prof. Phillips at the request of the British Association, the results of which are given and ably discussed by Prof. Phillips in the volume of Transactions of the Association for the year 1835. Three gauges were used in these observations: the first was placed on a large grass-plot in the grounds of the Yorkshire Museum; the second on the roof of the Museum, at an elevation of 43 ft. 8 in.; and the third on a pole 9 feet above the level of the battlements of the great tower of the Minster, at an elevation above the ground gauge of 212 ft. 10½ in. The total quantities of rain received by these gauges during the three years of observation were as follows:—

1st gauge	... ...	65·430 inches
2nd ,,	... ...	52·169 ,,
3rd ,,	... ...	38·972 ,,

From these numbers it appears that the ratio of increase of size of a rain-drop is 0·679 for the last 213 feet of its fall, and 0·254 for the last 44 feet.

A very able discussion of the whole series of observations, with reference to the temperature of the seasons, led Prof. Phillips to the following formula for calculating the difference between the ratios of the quantities of rain received on the ground, and at any height h, the value of the coefficient p depending upon the temperature t' of the season:—

$$d = p\,h\,\frac{t'}{110}$$

Calculated by means of this formula, the mean height of the point at which rain begins to be formed is 1747 feet; and the height at which the quantity of rain is only one-half of that which falls on the ground is 356 feet.

Assuming the mean temperature of newly fallen rain at York to be 48°, and taking the latent heat of vapour at 1210° at the temperature of 32° Fahrenheit—the value adopted by Prof. Espy in his Meteorological Reports and Essays—it will be found that a rain-drop cannot acquire the increase of size indicated by the observations by the condensation of vapour upon its surface, unless its temperature when at a height above the ground not exceeding that of the top of the tower of York Minster is below 434° Fahrenheit! From this result it is evident, that only a very small portion of the total augmentation of a rain-drop can be due to the condensation of vapour upon its surface, and that

* Read at the Literary and Philosophical Society.

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by far the greater portion must be owing to the deposition of moisture which has already lost its latent heat, or heat of elasticity, and which is therefore not in the state of a true vapour; although, on the other hand, its invisibility in the atmosphere under ordinary circumstances, in the form of cloud or fog, renders it difficult to suppose that it can be in the ordinary liquid state. We have just seen that at a height of 356 feet the quantity of rain is only one-half of that which falls on the ground; and it is evident, therefore, that a shallow stratum of the lower and comparatively clear atmosphere supplies as much rain as a densely clouded and much deeper stratum in the higher regions. As these remarkable results may raise doubts as to the general correctness of the methods of observation which have been used to determine the quantities of rain at different heights, I may here mention an important fact, for which I am indebted to my friend Mr. Binney, F.R.S. In descending the shafts of deep coal mines, Mr. Binney has observed that the drops of water which drip from the upper part of the shaft increase to an extraordinary size during their descent to the bottom. Evidently the same principle is here in operation as in the case of a raindrop falling through the atmosphere, and Mr. Binney's observation affords a valuable confirmation of the general accuracy of the results of the observations which have been made to determine the rain-fall at different elevations.

That the whole amount of a fall of rain is not derived from the direct condensation of vapour at the time that the fall takes place, is apparent from other considerations than those which depend upon the different quantities of rain at different heights. It is supposed by some meteorologists that the mild temperatures of the higher latitudes of western Europe are due to the heat which is liberated by the condensation of vapour during the frequent precipitations of rain which take place on or near the coasts; but if this view were correct, the mean temperature of rainy days ought to be considerably greater than the mean temperature of the year.

A discussion of the Greenwich observations for the years 1852-3-4, and of the Oxford observations for 1855-6-7, with reference to this point, has given the following results:—

Greenwich Observations.

Year.	No. of rainy days.	Mean temp. of rainy days.	Mean temp. of the year.
1852	152	51·39°	50·66°
1853	184	47·62°	47·49°
1854	145	48·80°	48·80°
General means	160·3	49·27°	48·98°

Oxford Observations.

Year.	No. of rainy days.	Mean temp. of rainy days.	Mean temp. of the year.
1855	140	49·84°	47·10°
1856	154	49·09°	48·70°
1857	146	49·96°	50·40°
General means	146·6	49·63°	48·73°

It appears, therefore, that the excess of mean temperature of rainy days over the mean temperature of the year, on an average of three years, is only 0·29° by the Greenwich observations, and 0·90° by the Oxford observations; but as the winds which bring rain come principally from warmer latitudes, the mean temperature of rainy days ought, on that account alone, to be greater than the mean temperature of the year. Dividing the winds into two groups, northerly and southerly, it appears from the Oxford observations that out of 218·5 days of fair weather in the year, the wind was from the northern half of the compass on 131·5 days, and from the southern on the remaining 87; but out of 146·5 rainy days the wind was from the northern half on only 64·5 days, and from the southern on 82. Moreover, the quantity of rain which fell with winds from the southward was nearly four-tenths greater than that which fell with winds from the northward. Calculating the mean temperature of rainy days from the mean temperature of the winds which prevail on those days, the result is 50·05°; but we have seen that the observed mean temperature is only 49·63°, or 0·45° less than the computed. It appears therefore that a wind accompanied with rain is, in general, sensibly cooler than the same wind attended with fair weather; and that whatever may be the mode of formation of rain, it may be regarded as a cooling process: and this view is borne out by the fact that the mean temperature of the days next after days of rain is sensibly less than that of the days of rain. According to the Greenwich observations the diminution is 0·29°, and according to the Oxford observations it is 0·19°. But if the vapour brought by a rainy wind retains its latent heat up to the moment that actual precipitation of rain takes place, the sudden disengagement of this heat, although occurring in the higher regions of the atmosphere, ought to have a very sensible effect in raising the mean temperature of rainy days; but as no such effect is produced we may conclude that the greater portion, if not the whole, of the moisture from which the rain is formed had previously lost all its latent and also a small portion of its sensible heat.

The questions now arise—1. What becomes of the enormous quantity of heat given off by the vapour which is condensed in the atmosphere? And 2, As the moisture which forms rain is not in the state of a true vapour, is it in the ordinary liquid state, or in some other state not hitherto recognised by meteorologists and chemists? With regard to the first question, it may be remarked that air nearly saturated with vapour has probably a greater power of radiating heat than dry air. The upper portion of a wind charged with vapour would therefore undergo a rapid cooling, and as the vapour which loses its latent heat does not immediately affect the transparency of the air, this process would go unchecked for some time, and would gradually extend to the lower strata; the vapour which had lost its latent heat would also gradually descend and accumulate in the lower atmosphere, until at a certain stage of the process clouds and rain were formed. This view of the subject is supported by the well-known fact, that the rate of decrease of the temperature of the atmosphere with the height is greater in rainy than in fine weather; and it appears likely to lead to a satisfactory explanation of many important atmospherical phenomena.

With respect to the second question, it is difficult to offer any plausible conjecture. There can however be little doubt that vapour deprived of its latent heat often exists to a considerable extent in the atmosphere without sensibly affecting its transparency; and indeed it often happens that the atmosphere is unusually transparent immediately before, and even during showers of rain, and when therefore it is strongly charged with vapour in this peculiar state.

Notwithstanding the cooling by radiation of the upper portion of a warm, moist wind, it is very probable that at a station on the surface of the earth the temperature would be found to go on slowing increasing, in consequence of the continual arrival of fresh warm air, until the moment when rain began to fall; the rise would then receive a check, and if the rain continued a decided fall of temperature would take place. If therefore we take a day of rain, the day before, and the day after, the difference of the mean temperatures of the day of rain and the day before ought to be less than that of the mean temperatures of the day of rain and the day after. It will be seen that this conclusion is borne out by the following results of the Greenwich and Oxford observations:—

	Mean temp. of day before rain.	Mean temp. of day of rain.	Mean temp. of day after.
Greenwich observations	49·25°	49·27°	48·98°
Oxford ,,	49·50°	49·63°	49·44°

Should the supposition that a considerable portion of the aqueous vapour in the atmosphere may lose its latent heat without becoming visible as cloud or fog be held to be inadmissible, it appears to me that we shall then have no alternative but to conclude that the generally received theory of latent heat is inapplicable to meteorological phenomena,—a conclusion at least as questionable as the view which I have ventured to advance.

RESTORATION OF LUDBOROUGH CHURCH, LINCOLNSHIRE.

This church, which has been closed for a lengthened period, was re-opened on the 2nd ult., after undergoing an extensive restoration. It is an ancient edifice, and possesses many features of interest. It consists of a nave with north and south aisles, chancel, and western tower, and from its great size may be ranked as a first-class village church, its extreme internal length being upwards of 100 feet, and its breadth nearly 50 feet. Its style is Early English. It was erected probably about the year 1190, the nave being the earliest work. The tower is of Perpendicular character, and belongs to the 15th century: there are portions of Decorated (14th century) work, as the south windows of the

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chancel and the windows of the south aisle show. In the spring of 1858 the nave was unroofed by a heavy gale, when upon examination the building was found to be in a very defective condition, and steps were taken to get the whole thoroughly repaired. The north aisle and the north arcade of the nave were in a very dilapidated state, and had fallen 17 inches from the perpendicular: they had consequently to be taken down and rebuilt, as had also the south clerestory wall and the chancel arch. In re-building the clerestory one of the old windows was discovered, and adopted as a model: it is a simple round-headed light, widely splayed within. The chancel is lighted by three deeply splayed windows on the north side, on the sill of the western one of which, on the removal of the old plastering, was discovered a very beautiful scroll painting, which has been carefully preserved. It is almost as fresh as when painted upwards of 600 years ago; the outline sketching of the design being still visible. At the east end are two similar windows of larger dimensions, with a quatrefoil in the gable: between the two windows externally there is a projecting buttress, which is somewhat higher than those at the angles, and has a band of dog-tooth moulding under the weathering. The south windows of the chancel are placed at a lower level, the original string-course having been cut away to allow of their being so placed. There is a good double piscina on the side of the chancel, which is worthy of notice: the water drains are foliated; and opposite to these is the old aumbry, the arched head of which is circular. The whole of the roofs are new, and are of framed timber stained and varnished, and covered with red tiles, those of the chancel being in strise of white and red: they are high pitched, and contrast very favourably with the flattened covering of the old church. The nave is upwards of 40 feet in height. The walls are built of the white chalk stone of the district in random courses, the dressings being of Ancaster stone. The contrast of the walls with the roof is very pleasing. The greater part of the area of the nave and aisles has been seated with open wooden benches. The stalls in the chancel are of a more elaborate character, and finished with open traceried fronts: the floors throughout, except under the seats, are paved with Minton's tiles. The pulpit, which is of good design, occupies the north-east corner of the nave. The windows are glazed with yellow-tinted cathedral glass, which gives a bright and cheerful appearance to the chancel. The quatrefoil in the east gable of the chancel is filled with stained glass, having the sacred monogram as a medallion.

The works just completed have rendered this one of the finest churches of the district, and an honour to the parish in which it stands. Taken as a whole, there are many points in the church which give it much interest to the mind of the antiquary. Mr. James Fowler, architect, of Louth, superintended the works, which have been very satisfactorily executed by Mr. Maxey, of Louth.

THE ISTHMUS OF SUEZ NAVIGATION PROJECT, CONSIDERED IN REFERENCE TO THE PHYSICAL IMPEDIMENTS TO ITS REALIZATION.

By W. A. Brooks, M. Inst. C.E.

There are probably few practical engineers who have not at one time or other turned their attention to the means of connecting the navigation of the Red Sea with that of the Mediterranean; and this because of the general belief that the levels taken by the scientific staff attached to the French expedition to Egypt in 1797, under the first Napoleon, had established the fact that the surface of the Red Sea was about thirty feet above that of the Mediterranean, as well as that nature presented no insurmountable obstacles in the form of highlands in the track which a canal would take directly across the Isthmus. Under these conditions the practical engineer saw no great difficulty in the construction of a channel of such capacity as to width and depth as should insure a powerful current through it, and thereby maintain a deep-water communication between the two seas, notwithstanding the influence of the prevailing winds and littoral current in drifting the alluvions of the Nile across the intended northern outlet of the channel. That even with the advantage of a difference of level of 30 feet, there still remained doubts as to the feasibility of keeping the Mediterranean entrance clear, is proved by the fact that the French engineers attached to the expedition preferred to establish a communication between the Red Sea and the Nile, rather than make a direct cut across the Isthmus as proposed by M. de Lesseps, and sanctioned by some of the members of the International Committee.

Even to this day the view in favour of a communication with the Nile is maintained by men of the highest professional standing, among whom ranks M. Paulin Talabot, whose work on the subject will be hereafter noticed when the question of realising a ship canal navigation by means of locks comes under consideration. The promoters of the project for forming a direct navigable channel, or open cut between the two seas, point triumphantly to the apparent natural facilities for reopening the navigation, and show that the great depressions of the soil which still exist below the level of the Mediterranean, in the shape of the Bitter Lakes and lakes Timsah, Ballah, and Menzaleh, require only to have the intervening barriers removed from between them to insure the return of the navigable channel which they assume to have existed at a former period. Here however rests the great error into which they have fallen! They base their hopes of reopening a communication which could only have existed whilst the strait separating the two seas had a length not exceeding the distance from Suez to the Bitter Lakes, or about one-seventh of the channel now proposed to be formed.

At an epoch beyond historical times, or when this natural bosphorus existed, the vast tract of land which now constitutes the Delta of the Nile, and contains about 3600 square miles of surface, must have formed part of a deep triangular bay of the Mediterranean, of which the apex was at Cairo, and the present shore between Alexandria and Pelusium constituted the base. At that period a narrow strait or bosphorus separated the continent of Asia from Africa in its then island form. The shores of this strait were formed by the termini or spurs of the mountain range on the African, and the high land on the Asiatic side, where they approach each other near Suez, and the whole length of the strait does not appear to have at the utmost extended northward of the southern end of the Bitter Lakes. A plain having an area of 3600 square miles, and a zone or belt of about 20 miles in breadth of Nile deposit beyond in the bed of the Mediterranean, attest the powerful nature of the alluvions of the Nile, with which the promoters of the Isthmus of Suez Navigation project have to contend.

The great transporting power of the current of the Nile, arising from the height which its surface attains when in a state of flood, is another difficulty in the path of the promoters of a deep-water outlet on the Mediterranean side. In time of flood the Nile has a fall of six inches per mile between the sea and a distance from it of fifty miles, and it is this excess of slope for such a powerful stream which causes the extension of the two embouchures of the Nile far beyond the general coast line, leaving as witnesses of the rapidity with which the channels of the Nile are protruded into the sea, the great lakes Mareotis, Edko, Brulos, Menzaleh and Sirbon, all of which form incomplete portions of the great Delta of the Nile, on their separation from the sea by the narrow belt of sand which is drifted up by the wave or driven by the wind from the mass of alluvions which are discharged from the Nile, and on first reaching the sea subside in the immediate vicinity of the mouths of the river.

The subject of the realisation of a communication by an open cut between the two seas is at the present day presented under a different phase from that of 1797, when a variation of level was supposed to have existed to the extent of nearly thirty feet. In 1847 careful levels were taken, and repeated in 1853, which levels so strongly corroborated each other that M. de Lesseps adopts them "as the only true levels." Those levels establish as a fact that the two seas may be considered to be level at the instant of low water in the Red Sea, and that the only variation which exists is that produced by the tide, which is at its maximum height during equinoctial tides when assisted by southerly gales, and at a minimum when the surface of the Mediterranean is raised by gales from the north and north-west, and that of the Red Sea is depressed by the same winds. During nine months of the year the wind prevails from north to north-west, and those winds alternate with south and south-easterly winds for the remaining three months; so that there is an almost constant tendency of the prevailing winds to elevate the surface of the Mediterranean, and to depress that of the Red Sea, or to diminish the small difference of level arising from the lift of tide in the Red Sea.

An examination of the levels which are given in the appendix to the Report of the International Committee, shows that during

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calm weather the two seas are nearly upon a level at low-water time in the Red Sea, and that the mean level of the Red Sea is only 2 ft. 2 in. above that of the Mediterranean.

Then, as regards the level of high-water in the Red Sea, compared with the mean level of the Mediterranean,

	Ft.	in.
During equinoctial spring tides the difference is	5	10
In ordinary spring tides ,, ,,	5	1
In ordinary neap tides ,, ,,	3	9

Lastly, as respects the influence of high winds upon the level of the surface of either sea, the following are the results of the observations which have been made:—A violent north wind in the Mediterranean raises the surface of that sea on the coast of the Isthmus to within $4\frac{2}{3}$ inches of the mean level of the Red Sea; also to within 1 ft. $11\frac{3}{4}$ in. of the mean of high-water of neap tides, and to within 3 ft. 3 in. of the mean of high-water of spring tides.

As regards the influence of the wind upon the Red Sea, the same observations prove that a gale from the south raises its surface 2 feet, while a northerly gale depresses it to the extent of 1 ft. 10 in. In the Red Sea the tide rises and falls above and below its mean level a maximum height of 3 ft. 4 in., and an average height of 2 ft. 7 in. during spring tides, and 1 ft. $3\frac{1}{2}$ in. during neap tides.

From the above data the velocity of the current between the two seas may be calculated,—the sectional area of the channel and hydraulic mean depth having been ascertained.

It is however an extraordinary circumstance, that while one set of scientific men (previous to the knowledge of the true state of the levels of the two seas which was obtained in 1847 and 1853) based their hopes of the success of the measure on the assumed great head of water or difference of level of nearly 30 feet between the two seas, there should subsequently be found another section of men of high scientific reputation who have been willing to consider it to be a matter of congratulation that no such great difference of level exists: thus, the portion of the International Committee who still sanction the project of an open cut and lend it at all events tacitly the weight of their names, divest their minds altogether of the value of that difference of level of 30 feet, which, if it had ever existed would have kept open the communication between the two seas probably to the present day, and now complacently assure the public that all their doubts as to the feasibility of the project are removed because of the small velocity of the current which the true head of water is capable of creating, and of the consequent stability of the banks or freedom from injury by scouring action. Thus the International Committee's report holds the following language on this vital question as to the scouring influence:—"The knowledge we possess of the relative levels of the two seas, and of the fluctuations to which those levels are subject under the influence of winds and tides, permits us to determine what will be the regimen of the waters in the channel, and the results of our calculations, which are annexed to the present report, have completely tranquilized all our anxieties. The highest degree of velocity which the waters can attain along the bottom, and which can only be for a short space, under the extremely rare combination of circumstances produced by the coincidence of a gale of wind from the south with the highest equinoctial tide, are as follows:—

"First,—If the canal be continuous from one sea to the other the velocity will be 3·31 feet per second, or about $2\frac{1}{4}$ miles per hour.

"Secondly,—If the canal be interrupted in its passage across the Bitter Lakes the velocity will be 3·80 feet per second, or about 2 miles 5 furlongs per hour in the section south of the Bitter Lakes; and 1·14 feet per second, or about four-fifths of a mile per hour, in the section north of the lakes where the soil is sand.

"Under the first system the banks would be exposed to injury from the plateau of Suez to the Mediterranean for an extent of $87\frac{1}{2}$ miles through sand, and locks at each extremity of the navigation would be indispensable. Under the second system the banks could only be endangered between the Red Sea and the plateau of Suez, and in those parts where the clay may not be compact. To dispense with the necessity for locks nothing more would be needed therefore than to protect those few weak portions that may be met with in the first $12\frac{1}{2}$ miles of the cut."

According to the plan proposed by the International Committee the cut or navigation is to be made from Suez to the Bitter Lakes, and from thence by a second cut to lake Timsah, and thence through lakes Ballah and Menzaleh to the proposed outlet on the shore of that lake. By this arrangement the promoters state that with the greatest head of water which can arise, produced by the coincidence of equinoctial spring tides and a gale from the south, the velocity of the current through the navigation will only amount to 2 miles 5 furlongs per hour between Suez and the Bitter Lakes, and to only about four-fifths of a mile per hour in the section north of the lakes. It is to be remembered that the velocities thus deduced by the Committee are greater than what would really occur, because they have assumed the high-water head in lieu of the mean rise of the tide.

The author agrees with the International Committee that they need be under no apprehension of the work failing by reason of the banks of the cut being destroyed by the velocity of the current: his fear—his belief, is that *the* danger to be apprehended is that of a want of sufficient velocity to keep the channel clear of sand, and that nature will find it a far easier task to ruin the works of the International Committee than she had to encounter in closing up the strait many ages ago.

It is indisputed that the mean level of the Red Sea is only 2 ft. 2 in. above that of the Mediterranean, and it has been ascertained that a violent north or north-west wind raises the level of the Mediterranean to within $4\frac{7}{10}$ inches of the mean level of the Red Sea Also, that with the same winds the surface of the Mediterranean rises to within 2 feet of the mean of high-water of neap tides, and to within 3 ft. 3 in. of high-water of spring tides. Those gales from the northward have also the effect of depressing the level of the Red Sea 1 ft. 10 in., or nearly to the same extent that they elevate the Mediterranean, so that at the instant of low-water in the Red Sea the surface of the latter is about 4 feet below that of the Mediterranean. It is therefore evident that on the recurrence of those winds there must be ample time for sufficient stagnation of the contents of the proposed channel to insure a deposit of all materials held in suspension in its waters. It may be reasonably assumed that the ancient strait or bosphorus became choked up by deposits of sand during the coincidence of strong northerly winds and neap tides.

The real grounds of apprehension of failure rest upon the want of sufficient difference of level, or head of water, between the two seas to prevent that stagnation taking place, and the following cases will illustrate what would be the condition of the channel if executed according to the plan of the International Committee.

The mean level of the Red Sea above the Mediterranean mean level, or head of 2 ft. 2 in., will give a velocity of nearly 2 feet per second, or about 1 mile 3 furlongs per hour, in the channel south of the Bitter Lakes. This same head of 2 ft. 2 in. will also give a velocity on the bottom of the channel of ·63 foot per second, or $3\frac{1}{2}$ furlongs per hour, if the channel were uninterrupted by passing through the lakes from sea to sea.

It has been shown that violent northerly winds raise the Mediterranean to within $4\frac{2}{3}$ inches of the mean level of the Red Sea; in this case the mean velocity of the current south of the Bitter Lakes will be 1·03 feet per second, or less than $5\frac{1}{2}$ furlongs per hour, and the bottom velocity only ·73 feet per second, or about 4 furlongs per hour. If the channel be uninterrupted from sea to sea the above small head of water will give a mean velocity of ·38 foot per second, or less than 2 furlongs per hour, and a velocity at the bottom of ·2 foot per second, or about one-seventh of a mile per hour.

From the above examples it will be at once seen that the silting-up process must take place throughout the channel, and that all sand or mud brought into it by the tides of the Red Sea will be deposited in the channel prepared for its reception.

It will now be as well to give the projectors the benefit of their assumption of the high-water head during spring and neap tides being constant quantities, and as such used in the calculations following; or the inquiry shall now be, as to the velocities at the time of, or with the head of high-water, commencing with the head of high-water of equinoctial tides when held up by southerly gales. In this extreme head of 6 ft. 10 in. the velocity at the bottom of the channel between Suez and the Bitter Lakes would be 3·71 feet per second, or about $2\frac{1}{2}$ miles per hour; but if the channel were uninterrupted between sea and sea the velocity would only be 1·22 feet per second, or about $6\frac{3}{4}$ furlongs per hour. With such a constant head the channel south of the Bitter Lakes could be kept clear, but a continuous channel between sea and sea would silt up. With a head of 3 ft. 9 in. above the mean level of the Mediterranean, or that of high-water of neap tides, the velocity at the bottom of the channel south of the Bitter

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Lakes would be 2·66 feet per second, or about 1 mile 6 furlongs per hour; but if the channel were continuous between sea and sea the velocity at the bottom would be only ·87 foot per second, or about 5 furlongs per hour.

On turning to the calculations given in the report of the International Committee it will be found that, as regards the rate of the current south of the lakes, they coincide sufficiently near for all practical purposes of this inquiry with those of the author; the greatest velocity of the current being 3·80 feet per second according to the Committee, and 3·71 by that of the author, for the district south of the Bitter Lakes, with this assumed constant head of 6 ft. 10 in. For the section north of the lakes the calculation of the Committee gives a velocity of 1·14 feet per second, which must be from the head or elevation of the surface of the Bitter Lakes above that of the Mediterranean.

The author in his calculation has however preferred to calculate the velocity supposing the channel to be continuous from sea to sea, and the velocity therein due to the above head of 6 ft. 10 in. only amounts to 1·22 feet per second, or, as aforesaid, about 6⅔ furlongs per hour, a velocity differing greatly from that given by the International Committee, who make it equal to 3·31 feet per second, or about 2¼ miles per hour; probably this will turn out to be some clerical error. In 1843 an able memoir on the subject of an open cut between the two seas was published by Capt. James Vetch, of the Royal Engineers, warmly advocating the realization of the project; that gentleman, like many others who were then favourable to it, being under the impression that the difference of level between the two seas amounted to 29 ft. 6 in., and on calculating the velocity due to that head of water Capt. Vetch correctly makes the velocity amount to nearly 38 inches per second, or at about 2·15 miles per hour, which he observes "is just the amount of current likely to be effective for scourage, and yet not difficult to navigate against." The above velocity deduced by Capt. Vetch for a head of 29 ft. 6 in. is very nearly the same given by the Committee for the high-water head of only 6 ft. 10 in., both being through a continuous or uninterrupted channel. The levels produced by the International Committee have established the fact that a sufficient head of water does not exist to create that continuous current from the Red Sea to the Mediterranean, which they themselves hold to be indispensable for the maintenance of the navigation.

The levels and other facts recorded by the Committee have also proved that during northerly winds, or for more than three-fourths of the year, there will be a current setting into and out of the canal, just as now takes place between the Mediterranean and lake Menzaleh; while there is nothing in them which can be advanced to justify the belief that it will be even possible to keep open so deep a channel between the proposed cut and the Mediterranean as that which now exists between lake Menzaleh and the sea, viz. about 3 feet.

On the subject of the currents between that lake and the Mediterranean, the report of the International Committee observes, that three separate mouths or channels now exist, viz., "the Tineh mouth, the Tanatic or Oum Fareg mouth, and the Ghemileh mouth (the latter is 421 yards broad, with a depth of 3 ft. 3 in. at low-water), and that the balancing of the waters of the sea and those of lake Menzaleh, the level of which is essentially variable, produces through these mouths alternating currents of considerable velocity, by which they are kept perpetually open." The waters of lake Menzaleh, which produce such insignificant results as regards depth of water, nevertheless cover an area of above 600 square miles. How comparatively pigmy must therefore be the effect produced by the discharge from the cut proposed by the International Committee!

The Committee, by the production of the levels showing the tidal rise in the Red Sea above the mean level of the Mediterranean, have destroyed the fiction that a continuous current capable of preventing deposit in the proposed cut would be maintained between the two seas. Friction in a narrow channel, evaporation from its surface, and the loss by filtration through the sandy soil of the Isthmus, and evaporation again by capillary attraction through the sandy soil by the sun's heat, would in weak tides leave but a very small portion of the tidal column to supply the channel north of the Bitter Lakes. The water of the Red Sea, except during very strong tides, would only find their way to the Bitter Lakes, to be evaporated and add to the huge bed of marine salt found in the borings taken there by the International Committee's orders.

The International Committee changed the site for the Mediterranean Harbour from the original position at Tineh, to a place on the shore of lake Menzaleh about 17¾ miles to the north-west, or nearer to the Damietta branch of the Nile, where their marine surveyor found 10 metres, or 32 ft. 10 in. depth of water, at 3000 metres (3280 yards) from the shore; and the Committee state that "the final question, or the most important of all, in the consideration of the project, was the deposit on or seaward advance of the shore, it having been imagined that the continual existence of any sea-works would be jeopardised by this cause." It will with difficulty for a moment be conceived that the promoters of the Isthmus of Suez scheme profess to have their fears on this head altogether allayed; because, as they observe, "no traces of mud are to be found along the shore, and the sand upon it is as pure as it is fine;" and they add, "this sand extends along the bottom without any mixture to a depth ranging from 8 to 10 metres (26 feet to 32 ft. 8 in.) The mud does not commence until beyond this range, and it is only at a depth of 10 metres that pure mud is found, and from thence it stretches out to an indefinite distance in the depths of the Mediterranean."

The author refers to the soundings taken for the International Committee, given on their chart, as well as to the whole of the borings given in detail in the appendix to their report, as warranting a totally opposite conclusion to that of the Committee in their language as above given. Thus, the letters "S.V.," *sable vase* (sand and mud), are affixed to soundings varying in depth from 12 to 23 feet, and "S.*f.*V." (fine sand mixed with mud) and "S.V." are affixed to soundings of 21 feet on both sides of the proposed piers at Port Saïd.

It is only by a superficial view of the bed of the sea that the International Committee's fears have been allayed as to the presence of mud, which could only be deposited in such shallow water during tranquil weather, as actually appears by their own words in another portion of their report. Thus they say, "The mud stirred up by the swell diffuses itself in the mass of water, and only settles down when the agitation has ceased. It is in this way carried to a distance and in various directions, according to the currents at the bottom and on the surface, without being arrested by irregularities of the bottom or by the indentations in the line of shore: on each occurrence of a heavy sea it is stirred up afresh, and eventually becomes lost in the great depths of the open sea, and in lake Menzaleh, where, no longer kept in motion by the action of the waters, it settles down, and forms a bed." Again, "The incessant shifting backwards and forwards which the sand and mud, deposited in the first instance near the shore, undergo in the sea, amounts to a sort of sifting and sorting process, by which they are eventually distributed according to their natural properties;—the sand is confined to the shore, while the mud is carried out into the open sea. In this manner has the alluvium of the Nile in process of time formed a zone of fine sand in the gulf of Pelusium, which, commencing at the beach, terminates at a depth of 8 or 9 metres (26 to 29½ feet) and reposes on a bed of mud of indefinite extent."

And now come the most extraordinary inferences ever yet professed to be deduced from facts, for the Committee proceed to say, that "the deposits of sand in the gulf of Pelusium are in point of fact as ancient as the Nile itself. Their growth in the course of ages has not been to any perceptible extent. As all mud deposits, whatever their magnitude, will to the end of all time be kept to the outside of the zone of sand, the shore line, which can only become upraised by fresh deposits of sand, may therefore be considered when taken in the mass as unchangeable. Any fresh deposits brought down by the Nile form accumulations which are confined almost entirely to its embouchure, the projection of which into the sea it augments to the extent of three or four metres every year. At all other points it keeps up the beach, but does not add to it. According to this showing therefore, the only objection to the direct track falls to the ground."

The author is of opinion that, according to the showing even of the Committee, the objection is sustained instead of being rebutted by the facts advanced. The only reasonable conclusion which the facts presented sustain, viz. those given by the borings and soundings, is, that where the alluvium of the Nile settles in deep water it remains undisturbed, and as such forms the substratum of a large portion of the Isthmus, the southern division having more of sand, or the influence of the deposit from the Red Sea, in the substratum, but where the deposit or alluvium of the Nile is deposited in shallow water, or that which has become shallow by the previous deposits of the Nile, the bed becomes

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exposed to the action of the wave, and the sorting process correctly described by the Committee takes place,—the mud and lighter particles are eventually carried seaward, and the sand or heavier portion is thrown forward on the beach; just as we see on the south-east coast of England the shingle thrown up, forming the beach, and the finer portion or sand occupying the position where a greater depth of water is to be found. From not understanding this very simple process many have conceived the idea that shingle does not travel below low-water, or at many feet in depth below it.

On the alluvions of the Nile being first discharged into the Mediterranean, the mud or lighter portion is carried further seaward than the sand or heavier portion, which is thus deposited near the mouth, and, on the occurrence of on-shore gales as above described, thrown on the beach.

That the mud of the Nile has been incessantly deposited is proved by the borings taken for the Committee. Thus the last boring to the north, or that nearest the site of the proposed piers of Port Saïd (No. 21, on the shore of lake Menzaleh), might and ought to have made the Committee more cautious in drawing up their report as regards the effects of deposit from the alluvions of the Nile. The contents of this boring the author now gives in the words of the Committee "sea sand, sand mixed with mud, and then mud with an admixture of sand."

The author by careful measurement of the boring No. 21 finds that pure sea sand is described as having been found from the level of the surface of the Mediterranean to a depth of 1·66 metre; then sand mixed with mud to a depth of 4·20 metres (from the same level of the Mediterranean), at which depth it changes to mud and sand to a depth of 12 metres, and the bottom of that boring at 13·66 metres (or 44 ft. 10 in.) from the same level of the sea is described as "mud containing a little sand."

In a review of the Isthmus of Suez project, which appeared in 'L'Année Scientifique et Industrielle, 1857,' warmly advocating that measure, the editor says that "the excavation of the maritime canal presents no difficulty. It is a soil almost entirely sandy, formed of the alluvions of the two seas, which it is easy to concede, if it be considered that at an epoch more or less remote the sea must have occupied the place of the Isthmus of Suez, and that this union of Egypt with Asia is but a result of the alluvions thrown up by little and little by the two seas, which are now only separated by a tongue of land."

The subject has hitherto been investigated without reference to any other facts than are presented by the tidal phenomena of the Red and Mediterranean seas as affected by gales of wind, and the detail of the natural condition of the Isthmus; but it may be as well to compare the case with that of other localities with which our readers may be better acquainted.

It appears that in reasoning upon the tidal influence of the Red Sea the International Committee have drawn no distinction between the tidal phenomena attending the propogation of the wave through the restricted channel by which it is proposed to connect the two seas, and those which arise when the tidal wave passes up a spacious channel. In the latter instance it is well known that the tidal column maintains the same sea level of high-water throughout its course, and even at some rivers exceeds the level of high-water at sea. Again, where the distance travelled by the wave is very great, and the momentum powerful, more than one high-water may be found in the channel; such as in fact takes place in the great rivers Maranon and Orinoco. Far different however is the effect on the tidal column where it enters a channel of confined dimensions, or where it experiences a stricture, such as would be the case in the Isthmus of Suez navigation, and it will therefore be useful to notice what takes place in rivers which as to the dimensions of their channels bear affinity to that of the Suez cut; or such examples as will by analogy show to how short a distance the feeble tidal wave of the Red Sea will be able to penetrate up the channel across the Isthmus.

The river Nene, which discharges its waters into Lynn Deeps, will in this respect afford an useful example. The rise of spring tides at the mouth of this river is 23 feet, and the tidal column enters it with a considerable momentum, but having to find its course up a restricted channel (although more capacious than that proposed at Suez), the effect of friction in the channel is so great that the tidal influence ceases at a distance of only 17 miles from the sea. The tidal column is depressed in its level so much by the resistance it encounters, that at that distance, where the lift of tide is barely perceptible, the high-water surface is actually 6 feet below that which the same tide previously had attained at sea, or in other words, the resistance to the tidal column arising from friction causes a loss of range of 6 feet of the flow at sea. The International Committee may have therefore reasonable doubt of their restricted navigation experiencing any tidal influence beyond the Bitter Lakes: the river Nene is a well selected example, because its outfall or mouth is by an artificial cut, very similar to that proposed at Suez.

In the example of the Nene there is, however, the advantage over the Suez project of a straight channel, in which the tidal influence is not paralyzed, as it will be on entering the Bitter Lakes, such as in fact takes place where the tide on passing Yarmouth enters lake Breydon, where a loss of tidal range is also felt. As an illustration of the depression of the high-water surface in a channel of a more circuitous nature, the tidal phenomena of the river Witham may be of service to refer to. This river also passes through a fen district, and has the same great lift of tide at its mouth as the Nene, viz. 23 feet in spring tides; but owing to the extremely circuitous nature of the channel in its natural state, the tidal column sustained a depression of its high-water surface to so great an extent, that at Tattershall, which in a direct line is only 18 miles from the sea, and was 23 miles by the old circuitous course, the high-water surface at that place was 11 ft. 6 in. below that which the same tide attained at sea.

This natural result or depression of the tidal column as it penetrates far inland (due to the friction on passing up a restricted and circuitous channel), enables large tracts of land to be readily reclaimed and brought into cultivation, although they may be many feet below the level which the tide attains at sea; the tide recedes too quickly to be able to penetrate far inland, and the main provision which land reclaimers have to attend to is to embank out to the level of the highest land floods.

The project of the Suez navigation by an open cut depends for its success altogether upon the waters which will fill it being free from the presence of sand from the Red Sea, and of the alluvions of the Nile. On this tender subject the International Committee state "In the first place the Red Sea can only carry along a very small quantity of sand, and no mud at all;" notwithstanding the soundings on their own chart within the wave stroke denote "S.V." *sable vase* (sand and mud). And then they proceed to state: "The deposits of sand and mud which form the shore line of the roadstead, or cover the bottom, do not experience any perceptible augmentation or displacement. The general configuration of the beach and banks is permanent, the current and the surge being weak. There is nothing therefore to fear from the Red Sea, and the sand which may be brought up by waves, when they rise, will be deposited in the channel; *it may be rolled along the bottom by the currents produced by the set from Suez towards the Bitter Lakes, but it would never go beyond.*"

This latter admission of the International Committee, as regards the distance to which the tidal influence will extend in carrying along sand, is confirmed by the natural condition of the Isthmus as per memoir by M. Renaud, which was read on the 19th of June 1856, at the Academy of Sciences, Paris, on the geology of the Isthmus of Suez. "In the whole extent of the Isthmus," says M. Renaud, "between the gulf of Suez and the bay of Pelusium, sand is alone found on the surface, more or less mixed with gravel, and more or less sterile. On setting out from Suez, as far as 6 kilometres from that town the sand is without any mixture of gravel, and appears to have been deposited, or at least spread, by the waves of the sea: on advancing towards the north the gravel is gradually visible, and at last becomes abundant in the most elevated part of the ridge which separates the Red Sea from the basin of the Bitter Lakes, but it is only found near the surface; it is also found, but in smaller quantities, in the basin of the Bitter Lakes, and particularly on their shores, where the gravel forms beaches which the waves have formerly left: the more progress is made to the north, the less is the gravel seen, and it disappears altogether at lake Ballah."

The author agrees with the International Committee that the sands brought in by the tide of the Red Sea will not be deposited beyond the Bitter Lakes, and this on account of want of sufficient velocity in the current, as already detailed. It must also be remembered that there will be a greater tendency to deposit sand in the channel because the discharge of the ebb will receive no acceleration by the existence of a fall in the bed seaward, such as is found in all rivers.

It has been proved by the state of the levels that there will be no continuous current through the canal, and that therefore the

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alluvium of the Nile will have free entrance into it when the surface of the Mediterranean is elevated on the north shore of the Isthmus by the prevalence of northerly winds or on-shore gales, such as is now found to occur in lake Menzaleh; and that therefore the promoters of the project, if they will have a communication across the Isthmus, must fall back upon the original proposition by Linant Bey and Mongel Bey, of a canal with entrance locks at either end, a measure which is practicable if the canal have its bed and side slopes properly puddled, and in which the promoters will have however to encounter the difficulty of keeping the loose sand-hills from drifting into it, and of making and maintaining deep-water channels of approach to connect the canal with the Red and Mediterranean seas; which the author however believes will be far too serious to make the work advisable to encounter, even supposing the value of money expended on it were of no consequence in comparison to the desirableness of realizing and maintaining the communication.

LIVERPOOL ARCHITECTURAL SOCIETY.

THE concluding meeting of the session of the Liverpool Architectural and Archæological Society was held on the 2nd ult., in the Royal Institution, Colquitt-street. The president, Mr. H. P. HORNER, read his closing address. In the course of it he said,—

"The question on which I dwelt at some length, when addressing you at the opening of our session,—the design for the new Foreign Office,—remains yet in abeyance, and bids fair for some time to continue so. Whether this will lead to any alteration or modification in the views of the architect, or of those who are to decide on the matter, remains to be seen; but the subject, whenever it may be revived, will scarcely, I think, have lost anything of its primary interest or importance. The main question involved—that of style—is extending to the colonies, the new parliamentary buildings for Canada having been designed in a style much resembling that of the Oxford Museum and the Manchester Assize Courts (the two last named having much in common), and a competition open for parliamentary buildings in Australia calls afresh for the consideration of the style, if one is to have precedence, best adapted as a foundation for modern architectural design, and affords occasion also for duly weighing the question as to the part which circumstances of climate, locality, and available materials should bear in determining in every case the form of design; and, should any of our members be engaged in the competition last named, or in others pending on the continent of Europe and in the Spanish peninsula, I would desire to press upon their attention how much they owe to the cause of sound architectural design, and to the reputation of their profession abroad, to throw aside prejudices and give earnest heed to the bearing which the points I have named and other cognate ones should have upon their choice of a style and their mode of treating it.

The differences lately existing between the metropolitan contractors and their workmen seem for the time to have subsided, but as usual have left many marks of their existence, and one most serious and, perhaps, not readily anticipated, in the increased mortality among the working classes of London. The returns of the registrar-general distinctly point out this effect, and if arguments were wanting to convince any of the folly of these disagreements in the form which, on the part of the workmen, they now usually take, this grave additional one should surely weigh with the classes it relates to, who in the end are almost always the losers, and who as a general rule are urged on by interested and designing persons to press demands often utterly incompatible with the true relations of capital and labour, and of the practicability or probable effect of which they are very little capable to form a judgment.

The death of the late noble President of the Royal Institute of British Architects occasioned a vacancy which has, much to the satisfaction, I believe, of that body, and of the profession generally, been filled up by the election of one of the veterans of the profession, and of one of its most learned and experienced members. It is to be hoped that this step may mark a new era in the management of this central body of our profession, as, however valuable to a new society the support and countenance of an intellectual and influential nobleman as its president may be, such a society as that in question, when once fully established, can only, according to all experience, be duly advanced and prospered by the directions and exertions of the leading members of the profession it represents.

The question of architectural examinations, not unfrequently mooted among us, has been made the subject of grave consideration, and of discussion and report, by a committee of the Institute, the result of which is published. The general object is undoubtedly a very valuable one, as tending to insure at least a competent degree of knowledge in those undertaking the profession of architecture, and the Institute of British Architects being the only chartered body in the profession, seems the fittest to undertake the responsibility such examinations would involve. But as regards the higher examination proposed for future fellows of the Institute, it seems to me highly improbable that the honour of that title will be often sought by men in established practice at the cost of the irksome ordeal which is proposed; and however desirable the proof that a new practitioner is competent for what he undertakes to direct, others whose works give them a right to the title which they assume may well be excused if they decline to seek admission to the leading body of the profession by the temporary negation of their claims implied in their submission to be examined as tyros.

The importance of iron as a constituent in architectural construction—a point I have before dwelt upon—is becoming constantly more obvious, and from time to time new forms of the material, in simple rolled bars, adapted for greater stress than has heretofore been laid on such, are presented to us. These, and the general substitution of wrought for cast girders, will certainly influence design, and it is well worth our thought how these can be best applied to insure consistency of design, as well as sufficiency of construction. As I have before taken occasion to say, my own opinion is opposed to the extensive use of iron where architectural impressions of importance are aimed at. Much of this may be the results of habits of thought, but much too, I think, is founded on principles of art; and I touch on the subject, which recent circumstances have recalled to my mind, to draw attention to the necessity of duly weighing such questions, if we are to have at once consistent architecture, and the full use of our present improved means of construction.

Recurring to subjects of local interest, a most liberal offer on the part of Mr. William Brown, to cover in a portion of the New Free Library and Museum, intended to have been reserved for purposes of future extension, and to devote it to matters connected with inventions in practical science, has been lately the subject of consideration by a joint committee of this society and others. The matter interests the architectural profession, as opening the prospect of a museum of new materials and applied science, and the community at large are much indebted to Mr. Brown for this further proof of his generous liberality.

No buildings of much importance have, I think, been commenced in Liverpool or its neighbourhood during our past session, but many have been carried towards or to completion, and the great business centre of the town gains year by year in the importance of its architectural features. The subject of the proposed Public Offices is equalled in interest by that of the projected improvements in the external and internal lines of communication of the town. It is to be hoped that the way may be seen to carrying forward these most necessary projects, which have a special interest for our society, as embodying many of the points recommended by the improvement committee organised in great part among ourselves; and to myself they have the additional interest, that they coincide in their general tendency and in several leading features with what occurred to me when engaging in the competition on town improvements some years ago.

The question of fire-proof construction, which perhaps I should have coupled with that of the use of iron in building, demands more attention generally than I think it has yet received; and I am reminded of it by the recent disaster to one of the leading buildings connected with benevolent objects in Liverpool. I cannot but hope that in the reconstruction of this, and in the erection of future buildings of the same kind and character, an endeavour will be made to secure greater safety for life than at present generally exists; and in this instance I feel sure that the able architect originally designing the Sailors' Home would heartily second such an object. The substantial and faithful character of the main building is evidenced by the small external damage it exhibits; and so firm an external frame would seem a most suitable recipient of fire-proof internal construction.

The question of lighting by gas is, in my opinion, likely to take a new form, and consequently to demand the renewed attention

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of architects through the economy which seems likely to result from the use of the lime light with mixed gases. We should do well to keep our eyes always open to such questions and their various advancing phases. An architect may at any time be called to give an opinion upon, or propose some new method or system of lighting, ventilating, or warming buildings; and unless he takes pains to keep his knowledge up to the mark of the continual progress of science in such matters, he may find himself at fault when he least expects it.

No branch of knowledge is foreign to our art, and neither the youthful student nor the experienced practitioner can safely neglect any opportunities of enlarging his stores of information on general art, on the various branches of physical science, or on the practical appliances at his command; and on the young and the practised alike it is the duty of those who have at heart the interest of their profession—of the general community—of civilisation and human improvement—to impress the obligation which they are under to make their profession honourable by the services it renders to the comfort, the happiness, and the intellectual enjoyment of their fellow-men."

INSTITUTION OF CIVIL ENGINEERS.

GEORGE P. BIDDER, Esq., President, in the chair.

April 17.—The president announced to the members that the late Mr. Joseph Miller, for many years a member of council, has kindly bequeathed to the Institution the sum of five thousand pounds, of which three thousand pounds would be receivable immediately, and two thousand pounds on the demise of a gentleman resident in the West Indies. The funds of the Institution would thus be materially augmented, as there would also be soon receivable the bequest of two thousand pounds from the late Mr. Robert Stephenson. To these amounts must be added the sum of nearly five thousand pounds, bequeathed by the first president, Mr. Telford; of two hundred pounds, presented by Mr. Charles Manby; and of one thousand pounds, which had recently been invested out of income. The total invested property would thus ultimately become:—

	£	s.	d.
Bequest from Thomas Telford	4894	12	4
Donation from Charles Manby	200	0	0
Bequest from Robert Stephenson	2000	0	0
Bequest from Joseph Miller	5000	0	0
Invested by the Institution	1000	0	0
	£13,094	12	4

The paper read was "*On the Efficiency of various kinds of Railway Brakes; with experimental researches on their retarding powers.*" By W. FAIRBAIRN, M. Inst. C.E.*

The present communication was based upon an inquiry which arose out of a report prepared by Colonel Yolland, R.E., for the railway department of the Board of Trade. That report gave the results of a large number of experiments with heavy trains at high velocities, made with 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 brake of M. Guérin. The conclusions arrived at being favourable to the brake of Mr. Newall, as well as partially to that of M. Guérin for some descriptions of heavy traffic, Mr. Fay made application to the directors of the Lancashire and Yorkshire Railway, for a further investigation of the subject. This permission was granted, and the author agreed to arrange the conditions of the trial, and to superintend the experiments.

The objects the author had in view were, first, to ascertain the retarding power of each of the competitive brakes; and secondly, to obtain some data in regard to the rapidity with which a train, with an engine and tender attached, could be brought to a stand when travelling at a high rate of speed; so as to determine the value of the continuous and self-acting brakes, as compared with those ordinarily in use, and with others recently introduced. To enable this comparison to be made, the experiments were reduced to a common standard, by means of a few dynamical laws, which were explained.

It was stated that, in the increase of the braking power of trains, the principles hitherto most successfully employed had been, first, the use of steam acting direct on the brakes; second, the connection of several of the ordinary form of brakes, so as to have them under the control of a single brakesman; and third, the introduction of braking apparatus connected with the buffers, so as to make the momentum of the train itself available in generating a retarding force.

A description was then given of the different brakes before alluded to as having been experimented upon by Colonel Yolland. It was mentioned, that Mr. Newall claimed the earlier application of a combination of brakes, acted upon by one guard through a longitudinal shaft; and that Mr. Fay had adopted the same principle, with very slight modification either in form or construction.

The mode of carrying out the experiments with Mr. Newall's and Mr. Fay's continuous brakes was then detailed, and the results obtained were recorded in seven tables, one for each set of trials. As in the reductions the value of the retarding force of the brakes was found in terms of the coefficient of friction of the rubbing surfaces, the efficiency of the brake varied with the condition of the weather. Thus the mean of the Oldham experiments gave a retarding force of 1·7987 feet per second; the mean of the first experiments at Southport 4·2978, and of the second 3·3245. On each day the experiments were consistent with one another, but they varied greatly on different days from the change in the condition of the rubbing surfaces. At Oldham the experiments were made with the rails in a greasy condition from fog. At Southport, in the first trial (table 2) with the rails dry and in the best state for braking, and in the second (table 3) with the rails slightly wet. These results were in accordance with the experiments of Morin, on the friction of iron on iron, from which it was found that the coefficient of friction varied from 0·05 to 0·3, according as the surfaces were greasy, wet, or dry. The remaining experiments were all made under the most uniform and favourable conditions. They were therefore grouped together under the following heads:—

1. On the friction of the carriages (table 4).
2. With slide brakes, and the engine detached (table 5).
3. With flap brakes, and the engine detached (table 6).
4. With the engine attached to the train (table 7).

The following table gave a brief summary of all the experiments, except those on the friction of the carriages, which was found to amount to 11·527 lb. per ton weight of train in Mr. Fay's case, and to 7·627 lb. per ton in that of Mr. Newall:—

	No. of experiments.		Average efficiency of brake.	
	Mr. Fay.	Mr. Newall	Mr. Fay.	Mr. Newall.
Oldham Incline, table 1 ...	7	7	1·8538	1·7436
Southport ,, ,, 2 ...	5	1	3·6256	4·9700
,, ,, ,, 3 ...	1	1	3·2329	3·4161
,, ,, ,, 5 ...	8	8	6·7030	5·4984
,, ,, ,, 6 ...	3	3	5·8718	6·3272
,, ,, ,, 7 ...	3	3	3·0934	3·0250

The general average from this table gave, for the efficiency of Mr. Fay's brake 4·0634, and for Mr. Newall's 4·1650, showing a slight superiority in favour of the latter. The following conclusions seemed to be borne out by the experiments:—1. That with slide brakes the greater number of experiments gave a manifest superiority to Mr. Fay. 2. That with flap brakes there was a decided advantage on the side of Mr. Newall. 3. That when the train was braked, with the engine attached, the results were uniform, neither gaining any decided superiority.

Colonel Yolland's experiments were then tabulated and reduced in the same manner as the author's, so as to admit of comparison with them. The results thus arrived at, in reference to two of the systems, were exhibited in the annexed summary:—

	Mr. Newall.	Mr. Fay.	Remarks.
Engine detached ...	3·5516	3·9345	Dry.
	3·017	3·255	Wet.
Engine attached ...	4·671, 5·146, 4·505	....	Mean 4·774

The final reduction of the retarding force to units of weight of brake carriages, was given in the following summary:—

Brake.	Weather	Experimenter.	Ratio of weight on the brakes to the retarding force generated by them, or the mean coefficient for each brake.
Mr. Newall's ...	Dry	Fairbairn.	From 0·1544 to 0·1965
,, ,, ...	Wet		0·0542
Mr. Fay's	Dry		From 0·1126 to 0·2082
,, ,, ...	Wet		0·0576
Mr. Newall's ...	Dry	Yolland.	From 0·1116
Mr. Fay's	Dry		0·1020
Mr. Ingram's ...	Wet	...	0·1075
M. Guérin's ...	Dry	...	0·01048
Mr. McConnell's ...	...	...	0·28325

Showing that the retarding force varied from the one-hundredth to five-eighteenths of the weight of the carriages to which brakes were applied, and was ordinarily from one-tenth to one-fifth.

* See *C. E. & A. Journal*, vol. xxii. p. 357.

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April 24.—The paper read was "*Account of the Works recently constructed upon the River Severn, at the Upper Lode, near Tewkesbury.*" By E. LEADER WILLIAMS, M. Inst. C.E.

The whole of the works constructed during the past fifteen years for the improvement of the navigation of the river Severn, between Stourport and Gloucester, were projected in 1841 by Sir William Cubitt. There had already been laid before the Institution communications descriptive of the mode of Blasting the Red Sandstone and Marl Rocks under Water (Min. of Proc. Inst. C.E., vol. iv. p. 361),* and an account of the works between Stourport and Diglis (vol. v. p. 340). It was only necessary therefore to state, in reference to those works, that the result of the experiment forced by parliament upon the promoters, to attempt to improve the navigation between Diglis and Ryall by dredging, instead of by the construction of a lock and weir at the latter place as proposed, was that, after having kept four steam dredging-machines constantly at work for upwards of two years, and having removed upwards of one million tons of marl, gravel, &c., it was found that the level of low water upon the lower cill of Diglis lock was depressed 3 feet, and that the required navigable depth could not be maintained.

Application was consequently again made to parliament for permission to carry out the works according to the original plan; but to meet the local requirements of the town of Tewkesbury, the site of the projected works was removed from Ryall, four miles above that town, to the Upper Lode, half a mile below it. After a contest in parliament of five years' duration, the requisite powers were obtained; but owing to the unfavourable state of the money market at the time (1852), the works were not commenced until the autumn of 1856.

As the channel of the Severn at the Upper Lode formed an acute angle, changing from NW. to SSE., it was determined to construct the proposed works in new channels, describing easy curves. In order to allow of the passage of a steam tug and an accompanying fleet of vessels, at one "locking," a basin or second chamber was added to the lock proper. This was entered by a pair of gates, and the bottom of both lock and basin being uniform throughout, the two together could be worked as one large lock-chamber 276 feet in length, and capable of containing, besides the steam-tug, six Severn trows, each of 100 tons burthen.

The depth of excavation required for the lock-pit was 35 feet, and here some difficulty arose, as was anticipated. Beneath 2 feet of loam and 16 feet of sound red brick clay, there occurred 14 feet of imperfect blue lias clay, intermixed with black mud and decayed vegetable matter, in which strong springs of water were met with, and then 4 feet of compact blue lias clay, overlaying a thick bed of water-bearing gravel. When the sound upper crust was removed, the semi-fluid mass began to rise in the pit, letting down the clay on each side, and breaking up the whole of the surface. At first it was suggested that the water should be drained off; but the proximity of the river, which surrounded the works on three sides, left little to be hoped for from such an attempt. Relief was therefore sought in another, and, as experience proved, the right direction. Pits were sunk in the line of the east wing wall of the lock forebay, the sides and ends being planked with half timbers, well strutted. As soon as the sound clay was reached, the pits were filled with concrete. The distance between these pits was 20 feet, and the intermediate soil was allowed to remain until the concrete in the adjacent pits was consolidated, when these spaces were also filled with concrete. Thus the whole of the wall foundations, composed of concrete 12 feet in width and 14 feet in depth, were got in. It was expected that this mass would, by its gravity, resist the pressure of the soft soil at the back, especially as the materials between the two lines of concrete had not been removed. But as the concrete walls were forced bodily inwards, 18 inches on each side, strutting timbers were introduced to prevent further movement; whilst an inverted arch of concrete, 6 feet thick at the crown, was gradually carried through the whole length of the work, upon a similar plan to that adopted in the case of the foundations of the side walls. As the timber struts did not seem to be sufficient to prevent the inward movement of the sides, during the formation of the inverted arch, counterforts of concrete 10 feet square, and carried 2 feet below the bottom of the side-wall foundations, were introduced at every 12 feet apart. The concrete foundations thus completed contained upwards of 7500 cubic yards.

The materials used in the construction of the lock chamber, invert, wing walls, walls of the basin, and lock gates, were then described. It appeared that the gates, which were 33 feet high by 20½ feet wide, were carried upon an iron pivot, with a hemispherical steel top, and were worked by one man with comparative ease.

The weir was 500 feet long, 40 feet wide, and 6 feet high. The apron, which was formed of rubble limestone, the face being pitched, had an inclination of 5 to 1 down to the lower cill, beyond which a horizontal stone sheeting extended to the width of 10 feet, for protecting the lower row of sheet piles. The section of the back pitching was a parabolic curve, which was continued over the cap cill, experiments having proved that this form facilitated the discharge of the water, instead of causing an up-heaving of its surface at the line of contact, which was common to other forms. The heavy freshes to which the Severn was subject were discharged by the weir with such rapidity, as to fill the channel of the river below it five times as fast as that above it, until the surface formed one unbroken plane, by the weir being thrown out of operation.

The old channel of the river was dammed up, by forming a jetty of fascines from each bank; every course of fascines being covered and weighted with stiff clay, well trodden into the thorns. Ultimately the dam was increased to a width of 130 feet, the towing-path being carried over it.

The estimated cost of the works was £35,000; and although the contingencies were unusually heavy this amount had not been exceeded.

The tugs used upon the river were 93 feet long by 19½ feet wide. They were propelled by paddle-wheels, worked by side-lever condensing engines, having cylinders 30 inches diameter and 4 feet stroke. One of these boats sometimes hauled up from Gloucester to Worcester, against the stream, at three miles an hour, twelve loaded Severn vessels, making a dead weight of upwards of 700 tons.

* See *C. E. & A. Journal*, vol. ix. p. 369.

May 1.—The paper read was "*On Coal Burning and Feed-Water Heating in Locomotive Engines.*" By D. K. CLARK, A. Inst. C.E.

The object of the paper was stated to be, to discuss and compare the existing practice of coal-burning on railways. In burning coal it was necessary to introduce air in such quantity as to maintain a sufficiently high temperature in the furnace, and so to distribute it amongst the solid and the gaseous portions of the fuel, as to effect the thorough mixture of the air and the gases. After noticing the insufficiency of the ordinary locomotive boiler in its normal condition for the proper combustion of coal, the author described the methods introduced within the last two years for admitting air above the fuel amongst the combustible gases. They were classed as first acting by currents of air introduced through tubular or other openings in the sides of the fire-box, uniformly distributed over the surface of the fuel; secondly, by deflection of a body of air introduced through the doorway or elsewhere, upon and over the surface of the fuel; and thirdly, by constructing large and spacious fire-boxes, with large grates and long runs. The third class, which was first in chronological order, was represented by the systems of Mr. McConnell, Mr. Beattie, and Mr. Cudworth. Of these, the first and second were made with combustion chambers projected into the barrel of the boiler, and the second had in addition transverse midfeathers, and brick arches and tiles, for the better mixture of the elements and the maintenance of the temperature; whilst the third consisted of an elongated fire-box, with an inclined fire-grate sloping towards the tube-plate. In the application of the first and second classes of smoke-burners, the problem resolved itself into the following conditions:—The immediate and thorough intermixture of a plentiful but regulated supply of air with the ascending smoke or combustible gases, at or near to the surface of the fuel. Practically it was found necessary for this object to operate from both the front and the back of the fire-box, with air-entrances, arches, and deflectors at the doorway, in various combinations. But such contrivances as dealt with air in bulk, though generally effective in preventing smoke, were stated to be usually attended by the escape of a considerable quantity of unconsumed air through the flue-tubes, and a difficulty in keeping up steam at high speeds. The various forms of door-way deflectors were also stated to be objectionable, in facilitating by their mode of action the suction of particles of coal through the tubes, and the burning of the smoke-box, unless counteracted by an internal arch. The author had found by experience that, to burn smoke when the engine was working, it was sufficient that the air should be admitted at or near the surface of the fuel, by air-tubes distributed over the width of the fire-box in the front and the back, without the aid of internal arches or deflectors. The draught of air through the front tubes was very strong when the engines ran ahead, carrying the currents into the middle of the fire-box, where they met the counter-currents from the back, effecting the mixture of the air and smoke, and preventing the suction of small coal through the tubes. But in all systems applied to ordinary fire-boxes operating by means of the draught available in a locomotive engine, aided when the blast was off by the steam jet in the chimney, range of power was wanting to overtake the extremes of intense ignition and rapid generation of smoke-making gases, immediately after the steam was shut off, or when fresh fuel was added; and to suit itself also to the quiet state of the fire when the glow and excitement subsided, as well as to all the varying conditions of a locomotive furnace. The means of extending the range, volume, and power of the air-currents, and of adjusting them to the wants of the furnace, were supplied by the instrumentality of jets of steam, employed by the author as means of inducting and accelerating currents of air. The steam-nozzles, with the air-tubes towards which they were pointed, were like so many miniature blast-pipes and chimneys turned into the fire-box; and they possessed relatively the same power of urging and creating draught. By this method of steam induction the air-currents were delivered with such precision and velocity as to sweep the whole surface of the fuel, and forcibly to distribute the air amongst the gases.

In practice it was only occasionally necessary to put the steam jets in action when the engine was at work, if the air openings were sufficiently numerous, as the action of the blast alone drew a large supply of air through them into the fire-box. The time when the full inducting power of the jets of steam was in demand, was immediately on the steam being shut off from the engine, on drawing up to a station or otherwise. Then

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the heat in the fire-box was fierce, and there was an extensive distillation of combustible gases, which were discharged as smoke from the chimney unless met and consumed by the inducted currents above the fuel. The intensity of the heat subsided rapidly, and the jets could be moderated as desired, and continued in action until the engine was again in motion. The in-draught of air into the fire-box could be regulated by the use of slides, or dampers over the air openings. But by so limiting the number of air openings, and consequently the supply of air, as to prevent any material excess of supply when the fire was in ordinary condition, the dampers might be dispensed with in practice without prejudice to the economy of fuel.

In making a general comparison between the various methods of coal-burning without smoke, there was the difficulty of the diversity of circumstances as to time, fuel, engine, and duty, to contend with. The performances of several engines burning coal, on different systems, and the same or similar engines using coke, had however been tabulated. It thus appeared, that of the three systems of extended fire-boxes, by Mr. McConnell, Mr. Beattie, and Mr. Cudworth, with nearly equal gross weights of engine, tender, and train (100 to 116 tons), and at about the same speed, the consumption of coal was as follows:—

		Per ton gross.
Mr. McConnell's	...35¼ lb. Hawkesbury coal per mile	... or ·31 lb.
Mr. Beattie's (with cold water)	...24 lb. Griff & Stavely ,,	... or ·235 lb.
Mr. Cudworth's	...26 lb. coking coal ,,	... or ·225 lb.

Of the systems of coal-burning grafted on the common fire-box, with passenger trains, comparative results were given of Mr. Douglas's, with a doorway deflector, on the Birkenhead Railway; Mr. Yarrow's, with a brick arch and air bars, on the Scottish North Eastern Railway; Mr. Connor's, with a brick arch and door deflector, on the Caledonian Railway; Mr. Frodsham's, with a doorway deflector and steam-roses in the fire-box, used by Mr. Sinclair on the Eastern Counties Railway; and the author's, with air-tubes and steam-inducted currents, used by Mr. Cowan on the Great North of Scotland Railway. It appeared that with eight to ten carriages the following were the performances:—

	Gross weight. tons.		Gross coal per mile. lb.		Per ton gross. lb.	
Mr. Douglas	... 90	.....	28·4	or	·32	(Welsh)
Mr. Yarrow	... 86	.....	25·7	or	·32	(Fifeshire)
Mr. Connor	... 88	.....	22·2	or	·26	(Lanarkshire)
Mr. Frodsham	... 93	.....	23·3	or	·25	(Stavely)
Mr. Clark	... 110	.....	21·0	or	·19	(Fifeshire)

Showing that, with the author's system, less coal was used with a heavier train than with any of the others. Similarly favourable comparisons were made in the working of goods engines:—

	Gross weight. tons.		Per mile. lb.		lb.	
Mr. Douglas	... 445	.....	60·2	or	·135	per ton gross
Mr. Connor	... 255	.....	37·3	or	·147	,,
Mr. Frodsham	... 228	.....	41·5	or	·182	,,
Mr. Clark...	... 305	.....	39·6	or	·130	,,

The Great North of Scotland Railway, on which the author's system was in full operation, was stated to contain long gradients, several of which varied from 1 in 100 to 1 in 150, with frequent curves; and the goods engines could take up these inclines thirty-five fully loaded waggons, 460 tons gross train weight, at 10 miles per hour.

In conclusion, it was stated that the author's system of smokeless coal-burning was distinguished from others by its simplicity, durability, efficiency, and simple management. There was no construction of any kind within the fire-box, and consequently no wear and tear by exposure to intense heat. At the same time that it commanded the entire range of the fire-box, it did not interfere with or impose extra labour in the management of the fire. The manipulation was simple, the air-tubes being placed at a sufficiently high level to command the surface of the fire at all times. The whole business of smoke prevention was comprised in the occasional operation of the induction jets, by means of a tap under the hand of the engine-driver, and the occasional aid of the chimney-blower to carry off the products of combustion. By the proper use of this system the fire might be "damped" or kept dull when desired, where an engine had to wait at a station, without raising the pressure of steam, as the forcible in-draught above the fire might be made to prevent a draught through the fire, and consequently to check or to suspend the combustion of the fuel; conducing both to safety and to economy, and favourably contrasting with other systems, in all of which a powerful blower in the chimney was needed when standing, incurring dangerous pressures and waste of steam.

In feed-water heaters it was stated that little had as yet been done, except by Mr. Beattie, whose apparatus though efficient as a heater, was found, it was believed, to be too complicated for general use, and difficult to keep in order. The author had recently introduced a simple and compact heater, in which the steam from the blast-pipe was projected into a short tube in conjunction with the feed-water, which was delivered in a thin annular sheet around the steam-nozzle. In this short tube or chamber the water was broken into spray by the steam; the steam was instantly condensed, and the water was raised to a high temperature, at or near the boiling point. It had given satisfactory results in a 20 H.P. stationary engine, and would shortly be applied to a locomotive engine. It was said to be well adapted for agricultural and other engines on wheels, where lightness and compactness were considerations of importance.

May 8.—In the course of the Discussion upon the foregoing paper "On Coal-Burning and Feed-Water Heating in Locomotive Engines," it was remarked, that the plan of coal-burning advocated by the author seemed to be similar to that adopted by Mr. Jenkins, and which had been some time in use on the Lancashire and Yorkshire Railway, except that in the former jets of steam were employed to accelerate the currents of air. Mr. Jenkins' system consisted simply in making a certain number of the stays hollow instead of solid, through which the air was allowed to pass, and mixing with the products of combustion, effected the prevention of smoke. Moveable slides were fixed on the outside, so that the apertures could be opened or closed at pleasure; and thus either coal or coke could be burned in the same engine. The system could be applied to old engines at an expense of a few pounds per engine, and was said to be simple and effective.

It was stated that the use of tubes through the sides, and in some cases the front, of the fire-box for preventing smoke, had been tried nineteen years ago by Mr. Samuel Hall, the pioneer of surface condensation, on the Midland Railway, and the same system was now practised on the Great Western Railway. The smoke, though then not entirely consumed, was believed to have been as effectually got rid of as at the present day. Formerly the defect was that the tubes were burned, but where coal could be obtained at much less cost than coke, a want of simplicity, or the necessity of slight additional repairs might be overlooked. When first brought forward an objection was taken to Mr. Hall's plan, that when an engine was standing at a station, black smoke was emitted. This was remedied by the introduction of a small jet of steam in the chimney, for creating a draught when the engine was at rest; but the noise thus produced caused the plan to be laid aside.

In regard to the general question of smoke prevention, it was argued that neither deflecting plates nor brick arches were needed; but only the introduction of a sufficient quantity of air, moderately diffused over the fuel. In 1856, the use of hollow stays and small jets of steam had been suggested by Mr. Robert Longridge, particularly for marine engine boilers, where there was a difficulty in getting the proper quantity of air through the tubes; but it was thought that in a locomotive the requisite quantity of air to consume the hydrocarbons might be introduced by the hollow stays, without resorting to steam jets.

As to the comparative heating powers of coal and coke, it was sometimes asserted that the same evaporative effect would be obtained from the coke made from a ton of coal as from the original ton of coal itself. This view was dissented from, and it was stated that careful experiments with Garesfield coal and coke showed the evaporative power to be as 100 to 89 respectively, weight for weight. In other words, 1 lb. of coal evaporated 12·54 lb. of water, whilst 1 lb. of coke evaporated only 11·16 lb. of water. But inasmuch as 100 tons of coal produced only 66 tons of coke, it was evident that while 1 lb. of coal would evaporate 12·54 lb. of water, the same weight of coal converted into coke would only evaporate 11·16 × ·66 = 7·44 lb. of water; so that the true proportion was as 100 to 58.

On the other hand it was stated, that with Midland coal, 20 cwt. of coal produced 11¼ cwt. of coke, besides other products, and 6 cwt. of coke evaporated exactly the same quantity of water as 7 cwt. of coal. Consequently there was a loss in converting coal into coke for the purpose of producing steam; but considered only in reference to weight, coke had an advantage over coal in the proportion of 7 to 6. It was believed that it was physically impossible to consume smoke, when once formed, without loss. In making experiments on the combustion of smoke, a self-acting apparatus had been applied to the boilers of a pumping engine, with the following results. 1. When the engine was well fired, without the admission of air above the fire, the consumption of fuel was 100, but in this case smoke was evolved in considerable quantity. 2. When the air was admitted in sufficient quantity to consume the smoke, without being shut off during any portion of the interval between the firings, the consumption of fuel became 120. 3. But when the self-acting apparatus was brought into operation, to exclude the air so soon as smoke had ceased to be emitted, then the consumption of fuel was reduced to 110.

It was contended, that in order to enable a proper comparison to be made between the amount of fuel used per mile and the gross load carried, the paper should have showed—1st, what was the greatest altitude surmounted in each case, the total length of the line, the ruling gradient, and its length; 2nd, what was the average speed per mile for the whole distance run; and 3rd, how many pounds of water were evaporated by 1 lb. of coal. On the Scottish North Eastern the passenger trains ran at about 35 miles an hour, whilst on the Great North of Scotland Railway the speed did not exceed 25 miles an hour. Again, in reference to the goods trains, the speed upon the Great North of Scotland Railway was about 13 miles per hour, whereas on the Caledonian Railway it was about 20 miles per hour.

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It was observed, that in attempting the general introduction of anthracite coal in locomotive engines in the United States for long and heavy traffic, it was found, that although there was no smoke it was difficult to keep up the steam, and the fire-box and fire-bars were quickly burnt out. Notwithstanding these objections to its use, anthracite was in some cases a cheaper fuel than wood. Anthracite coal was burned on the Reading Railroad at the rate of 120 lb. per mile, in engines weighing 28 tons, and carrying a gross load of 750 tons at from ten to twelve miles an hour, on a level. The evaporation of water was from 5½ lb. to 6 lb. only per pound of coal. A brief description was given of Phlegel's, Dimpfel's, and Boardman's boilers, which had been made to burn bituminous as well as anthracite coal, and were used on passenger as well as goods trains. Each furnished considerable space for combustion, and air was admitted in numerous fine streams over the fire. They were all, however, heavy and complicated, and inapplicable to existing stock. Within the last three or four years renewed attempts had been made to adapt the existing stock of engines to the use of bituminous coal. The difficulties consisted in the large quantity of coal required to be burned in a given time under an intense draught, and in the clinkery character of the coal itself. The engines were not heavier, on the average, than in England, nor had they more heating surface; but they burned more fuel, and evaporated one-fourth more water in a given time. In December 1856, Mr. G. S. Griggs, of the Boston and Providence Railroad, introduced a fire-brick arch below the tubes in the fire-boxes of some of the engines of that line. With a few holes for the admission of air above the fire this arch was found to improve the working of the fire-box, when burning coal. On the Iowa Central Railroad, the grates of the coal-burning engines were at one time covered with fire-brick, so as to leave only about two square feet of the original surface of the bars exposed; and of this area less than one square foot was air-opening. More recently, perforated door-plates and air-distributors, the latter set up within the fire-box, had been extensively adopted.

It was contended, that both theory and experience showed that the heating power of 1 lb. of coal was greater than that of 1 lb. of coke.

In reference to the asserted increase in the consumption of fuel when burning smoke, it was remarked that the quantity of air required for the perfect combustion of 1 lb. of Hartley coal was 149·4 cubic feet, at 60° Fah. and 30 inches of mercury. The result of experiments showed that, up to a certain point, the admission of air did not increase the temperature in the smoke-box, but decreased it; affording proof that it was not necessary to send in an excessive quantity of air above what was chemically required for combustion, and that the result of the admission of air was to increase the temperature in the chimney, and to decrease the temperature of the fuel.

It was stated in reply to the observations which had been made, that in a comparative trial of the author's system and Mr. Jenkins' on a metropolitan railway, on the same passenger engine and on the same duty, the former consumed 4 lb. per mile or 12 per cent. less coal than the latter; that the saving of coal by smoke prevention in locomotives had been found to be at least 18 per cent.; that the information demanded for the purpose of making a proper comparison was given in the paper; that it was of no use to state altitudes simply, unless particulars of inclines and length of trip were also given; that the average speed of goods trains on the Caledonian Railway, deduced from the service time tables, was 12 miles per hour, not 20 miles per hour, and on the Great North of Scotland Railway it was, by the time tables, 14¼ miles per hour, not 13 miles; further, that the average distance run between stopping stations was on the Caledonian 6¾ miles, and on the Great North of Scotland 4 miles.

The paper read was "*On Indian Railways: with a Description of the Great Indian Peninsula Railway.*" By Jas. J. Berkley, M. Inst. C.E.

It was remarked, that the reason why the commerce of India had continued so incommensurate with the resources of the country might be chiefly assigned to the want of proper communications. Indian railways would not as in England be the substitution of a perfect system of conveyance for other convenient means; but in many districts they would be the first introduction of any communication whatever adapted for the requirements of the country. It was not however on these grounds that they merited the attention of the Institution; but rather in the remoteness of the country, the peculiarity of its soil, climate, and labouring classes, and in the novelty of its physical characters, and of the materials it produced.

Since the year 1849, when the government took the first decided step towards the establishment of a system of railways in India, the formation of 4821 miles had been sanctioned;—636 miles had been opened for traffic,—765 miles were expected to be opened in the current year, and 864 miles in 1861. The estimated capital was nearly fifty-two millions and a half; of which sum the expenditure of upwards of thirty-four millions had been sanctioned, and more than twenty-seven millions had been subscribed. The arrangements under which Indian railways were being carried out consisted of—a government guarantee as the means of raising the requisite capital; the agency of incorporated companies to design, execute, and manage them; and government supervision to define the projects and control the proceedings and expenditure. The terms of the contract between the government and the companies were then briefly stated; and it was remarked that, as far as they had been brought into operation, they might be pronounced to have been successful, although attended with some disadvantages, which were pointed out, the principal one being delay, owing to the necessity for reference to many widely scattered tribunals.

Certain standard dimensions have been adopted for all the lines and the rolling stock, including a uniform gauge of 5 ft. 6 in., and a minimum clear width between the tracks of 6 feet.

The principal lines of the Great Indian Peninsula Railway, which it was the more immediate object of the paper to describe, were proposed to extend from the port and city of Bombay to join the East Indian line at Jubbulpore on the north-east, with a long branch to Nagpore, and to meet the Madras line at or about the river Kristna on the south-east.

The advantages of the situation of Bombay, in the centre of the western coast of the peninsula of India, of its safe and capacious harbour, as well as its recent preponderance of trade, distinguished it as the commercial capital. The produce of the customs had more than doubled in five years; and its commerce in merchandize and treasure, in 1858-9, exceeded thirty-four millions sterling, being nine millions more than the whole foreign commerce of India in 1848. Bombay stood in urgent need of new docks—enlarged custom-house premises—extended wharfage and quay accommodation, with covered sheds—large warehouses—and an improved system of landing cargo.

The first section undertaken was from Bombay to Callian, a distance of 33 miles, with a branch to Mahim 1¼ mile. It was called the experimental line—was commenced in February 1851—and the portion from Bombay to Tannah, being a length of 20 miles, was opened for public traffic on the 16th April, 1853. The principal works upon it were the embankment over the Sion Marsh; the two viaducts connecting the Island of Salsette with the Concan, in one of which there was a navigation opening, 84 feet wide, spanned by wrought-iron plate girders; and two short tunnels. The permanent way was chiefly laid with transverse wooden sleepers, but 6 miles were on iron pot sleepers; the rails were 84 lb. to the lineal yard, of the double T form, as far as Tannah, but beyond that they were only from 65 lb. to 68 lb. a yard, except on the two Ghaut inclines.

From Callian diverged the south-eastern extension to Poonah and Sholapore, and by the proposed extension to the river Kristna and the Madras Railway to Madras,—and the north-eastern extension to Nassick and Jubbulpore, to join the East Indian Railway from Calcutta, by which also a communication would be effected to the north-west provinces of India.

The first section of the south-eastern extension from Callian to Campoolee, a distance of 37¾ miles, contained no work of a special character, but was remarkable for the extraordinary floods and rapid torrents to which it was exposed on both sides. It had been made for a double line, but only one road had been laid. The average cost, exclusive of rolling stock, was only £4500 per mile.

The Bhore Ghaut Incline, which was expected to be finished about three years hence, was 15 miles 68 chains in length, with a total rise of 1831 feet. The steepest gradients were 1 in 37 and 1 in 40; short lengths of level and of 1 in 330 being introduced, to facilitate the working of the engine in the ascent. It comprised twenty-five tunnels, eight viaducts, a large quantity of retaining walls, upwards of one million and a quarter cubic yards of cutting, chiefly rock, and nearly two million cubic yards of embankment. The estimated cost of this incline was £750,000. It was divided into two banks, by what was called a reversing station at the eleventh mile. This subdivision was adopted to increase the length of the base, in order to flatten the gradients and reach a higher level, where the main features of the Ghaut margin, near Khundalla, were encountered. Without this expedient, the practicability of changing the direction of the line would have been confined to the effect of curves of small radius; but with the device of the reversing station the direction was altered at a very acute angle, by means of points and crossings. The peculiar difficulties upon this incline were the unfavourable nature of the hot and rainy seasons; fatal epidemics, which dismayed and dispersed the people employed upon it; the lofty and precipitous character of the ground, impeding the haulage of materials, and harassing everyone engaged in the operations; the extensive and sudden slips upon the mountain sides; the extreme hardness and solidity of the rocks; the scarcity of water, and the want of necessaries and comforts for the men.

The next section of the south-eastern extension, from Lanowlee, the summit of the Bhore Ghaut Incline, to Poonah and Sholapore, was 205¼ miles in length, of which 185 miles were already completed, with a ruling gradient of 1 in 132. The cuttings were in trap rock, moorum, and soil; and the embankments were composed chiefly of soil and moorum. There were 22 viaducts, 359 bridges, and 454 culverts, all built of substantial masonry. One peculiarity of this district was the violence and suddenness of the floods, which descended with scarcely an hour's notice, and gathered into torrents upon spots of which there was no trace or warning upon the surface of the country.

Beyond Sholapore, to effect the junction with the Madras line, the works had not been commenced.

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Returning to Callian,—the first section of the north-eastern extension, reaching to Kusarah, a distance of 26 miles, gradually climbed by steep gradients of which a great portion was 1 in 100, up the flank of a long mountain spur that projected from the Ghaut range. It contained upwards of half a million yards of cutting, chiefly trap and basaltic rock; and more than one million and a quarter cubic yards of embankment. There were 4 viaducts, 44 bridges, and 117 culverts. By means of this section 849 feet of the ascent were surmounted.

The altitude remaining to be overcome by the Thul Ghaut Incline, which was 9¼ miles long, was thus reduced to 972 feet. At 3¾ miles there was a reversing station, similar to that on the Bhore Ghaut Incline. The steepest gradient was 1 in 37. There were 8 tunnels, 6 viaducts, 11 bridges, and 34 culverts. The cost of the incline would amount, it was believed, to about £450,000.

The next section of the north-eastern extension ran from the summit of the Thul Ghaut Incline at Egutpoora, by Nassick, across the fertile valley of the Godavery and the Indyhadree range, along Khandeish, to Bhosawul, the point of junction with the Oomrawuttee and Nagpore branch. The principal works upon it were the viaducts over the rivers Godavery, Kadoo, Munnair, and Wangoor. The two former were composed of masonry arches, and in the latter the openings were spanned with triangular iron girders.

On the last section from Bhosawul to Jubbulpore, a distance of 328 miles, the operations were only in a preliminary state. The viaducts over the rivers Taptee and Nerbudda would be important works, having flood streams of 70 feet and 90 feet deep respectively.

On the Oomwaruttee and Nagpore branch, which was about 263 miles in length, the operations were only just commencing. The largest works would be the viaducts over the rivers Nalgunge and Wurdah.

It was mentioned that there was no tunnel on any of these lines beyond the Ghauts, comprising a length of 782 miles.

The general style of design for these trunk lines was derived from the model of the late Robert Stephenson's English railways. The character of the works was plain, substantial, and durable; such as would provide for the regular and expeditious conveyance of a heavy and increasing traffic in goods, and the accommodation of numerous passengers, at a moderate working cost, and at a reasonable expenditure in maintenance.

The geological nature of the country was volcanic. As affecting engineering operations,—the destructible nature of the slopes of cuttings and embankments made of the black soil; the facility of excavating moorum, its firmness for slopes and embankments, and frequent suitability for ballast; the advantage of having rock foundations for the crossings of rivers and streams, and also of being able to make tunnels without either lining or faces, and the fine quality of the stone for building purposes, and facilities for quarrying it,—were worthy of special notice. On the other hand, the black basalt was so extremely hard, as to render progress both tardy and expensive; and the mountains were in many cases so precipitous as to prevent the sinking of shafts, thus limiting the mining of tunnels to two faces only. The existence of large quantities of kunkur, a variety of fresh-water limestone, and the want of good brick earth, were also mentioned.

The physical geography of the districts of Western India traversed by the Great Indian Peninsula lines might be briefly described as the plain of the Concan, elevated very little above the level of the sea. Then the abrupt scarp of the Syhadree mountains, the least altitude of which above the sea was about 2200 feet, and beyond them the plain of the Deccan on the south-eastern extension, gradually sloping down towards the eastern coast of India; while upon the north-eastern extension the country presented the bold features of the rivers Taptee and Nerbudda, with three parallel chains of mountains called the Indyhadree, the Santpoora, and the Vyndhya ranges. The altitudes of the various known spots along the railway were then given, including amongst others the following:

	Feet above high-water mark at Bombay.
Level of ground at Bombay terminus	11
Foot of Bhore Ghaut Incline	196
Top of ditto	2027
Foot of Thul Ghaut Incline	940
Top of ditto	1912

The extraordinary quantity of rain which fell during the monsoon from June to September, was then alluded to; and it was stated that the heights of known floods, where the railway crossed some of the principal rivers, varied from 25 feet at the Waldhur, to about 70 feet at the Taptee, and 90 feet at the Nerbudda.

The materials procurable in India for railway purposes were then succinctly noticed. In reference to the manufacture of Indian iron and the supply of coal, it was remarked that active and successful operations depended more upon the completion of railway communications, than the railways did upon a local supply of those materials. The properties of a few of the various kinds of wood which had been extensively used were then stated. Those which had been successfully converted into sleepers were teak, blackwood, khair, errool, and red eyne. The cost of a sleeper varied from 4*s.* to 7*s.* 7*d.*, the average price being about 6*s.* Tolerably good bricks had been occasionally procured, and used in arches, but in such cases a proportion of only 20 per cent. had been selected from the best native kilns: the price ranged from 10*s.* to 24*s.* a thousand. Gunpowder cost, when made upon the spot, about £34 per ton.

Native labour, by which these works had been executed, was cheap, but very inferior to that of England. Nearly one hundred thousand men had been employed upon the Great Indian Peninsula Railway lines at one time, and as many as twenty thousand on the Bhore Ghaut Incline alone. The wages of the several classes per day were now—native maistries, or foremen of masonry, brickwork, or carpentry, 2*s.* 6*d.*; masons 1*s.* 9*d.*, bricklayers 1*s.* 3*d.*, carpenters 1*s.* 6*d.*, smiths 2*s.*, miners (a very large class) 9*d.*, excavators 7½*d.*, and labourers 6*d.* The following table was given of the relative cost of each kind of labour in England and in the Bombay presidency; it being understood to refer to simple labour only, and not to the cost of finished work:—

	Proportion of work done by each.		Relative cost of labour in each country.	
	England.	Bombay.	England.	Bombay.
Masons	2½	1	1½	1
Bricklayers... ...	4	1	1	1
Carpenters	3	1	1½	1
Miners	3	1	2½	1
Excavators... ...	4	1	1½	1
Labourers	3½	1	1½	1

The whole of the Great Indian Peninsula Railway had been executed by contract, and this it was believed had led to remarkable economy in the construction of the various lines. The average cost of the opened portions had been about £8000 per mile. The introduction of the contract system into India on a large scale was an important effect of railway enterprise, and it was thought that its advantage could not be long confined to railway construction.

The prices of the principal kinds of work, including all the usual contract stipulations, had ranged as follows:—

Earthwork in embankments, under ½-mile lead,	6*d.* to 7½*d.*	cubic yard.
Cutting in earth or moorum	ditto	7½*d.* to 9*d.* ,,
Ditto rock	ditto	13*d.* to 30*d.* ,,
Tunnel		£21. 10*s.* to £33 ,,
Brickwork in arches		15*s.* to 30*s.* ,,
Coursed rubble masonry in arches ...		27*s.* to 36*s.* ,,
Ashlar		1*s.* 7½*d.* to 3*s.* cubic foot
Block in course		16*s.* to 35*s.* cubic yard
Coursed rubble		14*s.* to 24*s.* ,,
Rubble		9*s.* to 14*s.* ,,
Woodwork, teak		4*s.* to 6*s.* cubic foot
Ballast		13½*d.* to 16½*d.* cubic yard
Laying permanent road		2*s.* to 2*s.* 10½*d.* lineal yard
Post and rail fence		18*d.* to 24*d.* ,,
Dry rubble wall		2*s.* 6*d.* to 4*s.* ,,

This did not include the Ghaut inclines, which were exceptional.

Railway enterprise had already produced important effects in Western India. It had earned at a remarkably low tariff more than the guaranteed dividend. The working expenses had been low, notwithstanding the dearness of imported fuel and European superintendence. It had afforded the advantages of the best mode of conveyance to immense numbers of the poorest and lowest orders of the people. It had generated for itself new sources of traffic. It had achieved its success in competition with water carriage, and when it was only in a fragmental state. Although constructed in what was erroneously called an expensive style, the traffic had already demanded the partial laying of a second line of rails. It had raised the wages and increased the effectiveness of native labour, and profitably employed thousands of the carriers of the country. It had opened quarries and brickfields, had impelled trade into unwonted activity, and drawn largely upon the resources of the country. It had lessened the expenditure of the state by its cheap conveyance of mails and troops, and had augmented its income by large payments of tolls and duties.

ST. MICHAEL'S CHURCH, CORNHILL.

THE completion of the alterations and decorations at this church, and its having been re-opened during the past month, enables us to resume and perfect the description of what has been done, after the brief allusion to the subject in our April number. The whole of the recent works have been internal, the principal being the entire refitting, and the filling of all the windows with stained glass. As regards the fabric, it remains pretty much as when Wren left it. It has however been thought expedient to subdivide the long semicircular-headed windows of the north aisle into two lights, having a central shaft inside and a pilaster outside, with a circle above and between them, fitting in the space of the old inclosing arch. The originally circular clerestory windows, too, have been converted into "wheels," by radiating shafts united by round arches. Some slight modifica-

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tion has been made in the large circular east window, besides the carved alabaster reveal which it now shows; while the west window is entirely new, accommodated to the leading lines of the tower, and taking the place of an insignificant window with a still more puny door beneath. This last innovation became all but imperative when the organ gallery, which had entirely cut off the true relationship and proportions of the tower, was taken down;—indeed the result, as we now see it, is in the highest degree satisfactory. When we have added that in place of the ordinary-looking consoles, from which sprung the groining to the nave, there have been substituted a series of stone corbel-angels,—full-length figures bearing labels,—we believe we have touched upon all the substantial deviations from the original design.

A church has existed on this site from a very early period, and Stow, the antiquary, gives some curious historical information and statistics in his 'Survey of London.' Among other remarks he has the following:—"This hath been a faire and beautiful church, but of late years, since the surrender of their lands to Edward VI., greatly blemished by the building of some tenements on the north side thereof, towards the High Street, whereby the church is darkened and otherwise annoyed.....The faire new steeple or bell tower of this church was begun to bee builded in the yeere 1421." The church was destroyed by the great fire of 1666, except the great tower. The body was first rebuilt by Wren, and fifty years later the tower itself, 130 feet high, "in imitation of the splendid chapel tower of Magdalen College, Oxford, built in the 15th century."

The new fittings consist of pulpit and desk, chancel and choir seats, clerk's desk, churchwardens' seats, and a series of ordinary seats in the area of the nave and aisles. There being no actually distinct chancel (unless a recess of a few feet at the east end be so called), one bay of the church is now appropriated for that purpose and is separated from the aisles by slight perforated panels of scroll-work reared above the backs of the last choir seat. The pulpit is against the south pillar of this adapted junction, and the reading desk is against the north. There is no lectern. The font is at the west end, central under the tower; the bowl is octagonal, of statuary marble, and bears the date 1672; it is now mounted on a new pedestal, partly of Devonshire and partly of Sicilian marble, and stands on a single step made of the latter material. Near it, and supported on a marble pillar attached to the west wall, is a beautifully-carved pelican, in wood, gilt, which is said to have been executed by the celebrated Grinlin Gibbons, and which formerly stood over the altar-piece. The pulpit is of oak, on a Portland stone base, with marble shaft. At each angle is a twisted pillar, after the manner of Peter Cavalini, and the hollows in these twistings are filled with varied leaf-devices. The cornice is enriched with sprigs of hawthorn, in subdued relief. The hand-rail is peculiarly rich, and in brass. The reading-desk is of two sides, facing respectively south and west: each consists of two open arches, the centre pillars being round, resting on square bases, and on each of the angles is the head of a dragon, in reference to the prowess of the patron saint. The seats in the chancel have elbow ends, and there is a light oak book-desk in front on each side. The perforated screen-panels before alluded to are of foliated scroll-work, interspersed with sacred fruits and emblematical flowers, such as the lily, pomegranate, passion-flower, figs, olives, and trefoli. Each of the bench-ends in the church is surmounted by a suitably carved device, by way of finial, and we believe we are correct in stating that no two are alike. Among the subjects introduced among their enrichments we may mention—the pelican "in her piety," the vine, rose of Sharon, lily, sage plant, passion-flower, ivy, anemone, cluster of figs and leafage, the scape-goat, stork of the wilderness, oriental mitre, common flowers of the East, &c. The seats have plain panelled doors. In the centre aisle are, the Royal pew on the extreme right, and opposite, the Diocesan pew; then the City or Corporation pew, and, further westward, those of the Worshipful companies of Drapers, Clothworkers, and Merchant Taylors, each having its appropriate carved symbols and inscriptions. The Rector's pew has, on the front, the ecclesiastical shield, with the family motto and crest: on the inside is the monogram of the rector, surmounted by a branch of olives. All the bench-ends in this aisle have a shield on the outside, heraldically charged, and inclosed by well-developed foliage; on the insides are carved various fruits and flowers, such as, the gourd of Jonah, Syrian dates, nut fruit, oak-leaves and acorns, chesnuts, vine and wheat ears, mulberry, pine fruit, olives and figs. The churchwardens' seats are at the west end, the panels of the framing containing the monograms of the gentlemen in whose term of office the refitting has been accomplished, and above their seats is a draperied canopy, supported by richly ornamented brass brackets. At the west entrance to both north and south aisles are low metal gates of a quatrefoil pattern inclosed in squares.

The stained glass forms, as we have before remarked, an important feature among the improvements. The window at the west end of the south aisle (which is the one usually first approached) is emblazoned with the royal arms, and those of the patrons of the living,—the Drapers' Company, surmounted by those of the present Bishop of London. In the first window of the south aisle is a representation of the Annunciation, and Zacharias visited by the angel Gabriel; the magi bringing presents, guided by the star, to the manger, where are Joseph, Mary, and the infant Saviour: above are groups of angels. The second window has for its subjects John the Baptist preaching in the wilderness, and Christ being baptized in Jordan. The third window represents in one compartment the return of the Prodigal Son, and, in the other, the Good Samaritan, Christ preaching on the Mount of Olives, and the multitude listening to him. The fourth window shows Judas receiving the thirty pieces of silver, his betrayal of our Lord to the soldiers; Christ praying in the Garden of Gethsemane, with his disciples asleep; underneath, Christ is represented bearing his cross; and above the whole is an angel bearing the cup for him to drink. At the east end of the south aisle are seen, the women coming to the sepulchre to embalm the body, when the angels inquire,—"Why seek ye the living among the dead?" There are no windows whatever in the north aisle, the houses in Cornhill abutting close upon the church. The east window is a large circular one, containing the subject of the Ascension, surrounded by a bold geometrical border: the principal figure is 8 feet in height. The west or tower window represents the Crucifixion, with the Maries, and Joseph of Arimathea. The windows at the sides of the tower, as well as in each clerestory, are filled with geometrical patterns, as are also those north and south of the communion table.

The reredos is principally of alabaster, inlaid with various marble panels and mosaics, and having enriched cornices and pilasters carved in the solid. There are three panels behind the communion table, the centre containing the Alpha and Omega monogram, with the words "Peace be unto you," inscribed on a ribaud below,—the whole of the panel behind being richly diapered. The panels at the sides contain two old oil paintings, which belonged to the former altar-piece, and represent Moses and Aaron. They are painted by Straiter, serjeant-painter to king Charles II., and an artist of some celebrity in his day. The commandments, Lord's prayer, and creed, are gilt upon marble panels against the north and south walls.

The whole of the east end, the ceilings generally, and the aisle walls, are profusely decorated in colours, with geometrical ornaments and gilding freely used. In this department the utmost care has been exercised in rendering every portion worthy of its object, and yet preserving a harmonious balance of tone throughout. In securing this effect, as well as producing variety, we may observe that the decoration of the organ pipes, which occupy the eastern bay of the north aisle, is of the most delicate diapering, admirably effective in combination with the rest of the work. The instrument itself is well-known as a large and noble one, of wondrous power and sweetness, and it has now received sundry additions and improvements at the hands of Messrs. Robson, of St. Martin's-lane. The paving throughout the church is of ordinary flag-stones; in the chancel it is of black and white marble, laid in diagonal squares, and with black marble borders: some of the steps too are in this material.

The altar-rail is wholly of brass, of a rich scroll pattern, in harmony with that of the pulpit; the gas standards, brackets, and pulpit lights, being also of brass, considerably heightens the brilliancy of the general effect. The whole of this portion of the work was entrusted to Mr. Potter, of South Molton-street; and in addition to the particulars we have already given, should be added the names of Messrs. Trollope and Sons, of Parliament-street, the decorators (with whom should be associated Mr. R. Beavis as designer),—Mr. J. B. Philip as stone and marble sculptor, and Mr. Baily, of Gracechurch-street, as having supplied and arranged the warming apparatus and gratings.

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ANCHORS, &c. FOR THE MERCHANT SERVICE.

THE following report has been made by the parliamentary committee appointed to consider the above subject:—

"1. That at the outset of this inquiry it was established in evidence, that the loss of chain cables by parting and of anchors by breaking, is of rare occurrence in Her Majesty's Navy; and that this appears to arise from their having been subjected to a sufficient test before they are received from the contractors, and also from their being thoroughly examined, and in many cases re-tested, when returned into store, or before they are again issued for service.

2. That a variety of witnesses, chain-makers, shipowners, engineers, and persons conversant with shipping, examined before the committee, concur in the opinion that it is highly expedient that chain cables and anchors for the merchant service should be subjected to an adequate test before they are used, as it would be the means of saving much life and property.

3. That a considerable proportion of cables now made for the merchant service are of inferior iron and defective workmanship.

4. That the corporation of Liverpool and harbour trust of that port have for many years employed a testing machine of limited power, which is kept in full employment; and that since this inquiry was ordered by the House of Commons, it appears that the harbour trust, to meet the demands of that port, have decided on the erection of machines of greater capacity and power. That it is also in evidence, that during a period of five years, of cables sent to the Liverpool testing machine 82½ per cent. are imperfect cables.

5. That in Sunderland two testing machines have been for some time in operation, which, although private property, are accessible to all, and that the superior character of chain cables made in that district is in a great measure due to the results of these testing machines.

6. That from the evidence of all the witnesses examined your committee has formed the opinion, that nothing but the use of proper testing machines can afford any guarantee for the soundness of cables or anchors, as defects may exist, either from badness of material or imperfect welding, which no inspection can detect; and so closely can the tenacious quality of iron be calculated, that chains may be made to bear a given strain, which would break if the least excess of it were applied.

7. That though instances have been adduced by some witnesses to support the opinion that the application of a severe strain in testing has an injurious effect on a cable, this idea seems to the committee to be completely refuted by the evidence of Mr. Willcocks, and by the results of experiments made at Woolwich, and referred to in his evidence.

8. That all the witnesses examined agree in the utility of a test, and some of them, including all the manufacturers of chain cables examined, desire that its use should be compulsory, as many cables are now sold with false certificates.

9. That good grounds having been established in this inquiry for recommending the adoption of public tests, the only questions which remain are, the authorities into whose hands this duty should be confided, and the regulations that should be enforced.

10. That your committee are of opinion that bodies enjoying the confidence of the mercantile and shipping interest, and whose local residence will insure an adequate superintendence (such as dock trustees), are the proper persons to undertake this duty; and that the regulations under which they act should be approved of by the Board of Trade.

11. That in order to suit the convenience of manufacturers of chains and anchors who have testing machines on their own premises, the Board of Trade, on receiving a requisition from any such manufacturer, should appoint inspectors to attend the testing of any chains or anchors, and give certificates, according to printed regulations to be framed for that purpose, of the strain applied to them, which should be the test applicable to their size.

12. That although the committee cannot overrate the advantage of having the chains of every vessel subjected to a test, they are unwilling to recommend that the test should be made compulsory, but as they have recommended the general use of testing machines, they consider that all ships launched after the 1st January 1861, which come under the provisions of the Passenger Act, or are employed by any department of Her Majesty's government, either in the conveyance of emigrants or troops, should be required to produce certificates that their cables have been properly tested."

REVIEWS.

Throndheims Domkirke: or, The Cathedral of Throndheim. The Text by Prof. P. A. MUNCH; the Drawings by H. E. SCHIRMER, Architect.—Christiana, 1859.—London: John Weale.

(*Concluded from page* 154.)

IT would seem that the first step of Eystein was the erection of transepts, the original church of Olaf Kyrri being retained and used by him as the chancel of his new foundation. A nave —doubtless part of his plan—if built by him, must have been afterwards pulled down, as must also the eastern part, or the old church, the present remains of both showing the work of a later period, as will be hereafter more particularly noticed. These transepts are still existing parts of the present church, and have all the characteristic marks of the Anglo-Norman style prevalent in Eystein's time. In the Plates 2, 7, 8, 10, 11, 12, and 13, given in the work, this is very fully and carefully shown, and the observations in reference to them clearly establish their designed attachment with the older church as portions of the new, and the intended use of them therewith; a fact still further strengthened on view of Plate 7, which gives an interior of the chapter-house, the style of which is the same generally as that of the transepts. In relation to the evident original connection and use of this chapter-house also with the church of Olaf Kyrri, as the chancel or choir of Augustine's, we cannot do better while on this point than give the words of the work itself, because they bear out in every way the notion of Augustine's following a practice not only natural under the circumstances, but constantly observable amongst the church builders of his and succeeding times. These words are as follows:—

"That in the original plan only a chancel without aisles was intended, consequently not broader than the present middle nave of the chancel [the church of Olaf], may also be inferred from the evident traces found in the chapter-house of another combination between this building and the chancel than that now existing. This structure appears to date from archbishop Augustine's times. In its present shape it contains some parts younger than the Norman times, especially the pointed arches over the shafts and the pointed vault; but the former, at least, bear evident traces of not forming a part of the original plan, and the same is probably also the case with the whole ceiling, which bears the same sign as the arches of belonging to the earliest period of the first Pointed style, viz. the roundness, which makes the pointed arch seem nearly semicircular. Lights and doorways are all semicircular arched, and the style in general is of a massive kind, which seems only to belong to the Anglo-Norman period. The foundation of the chapters making chapter-houses indispensable, it might even seem probable that this little building was already begun during the life of archbishop John. This however cannot well be, all things duly considered, as even the semicircular arched parts of it, especially the arrangement of the windows in the western gable, looks younger than the main part of the transepts, but coeval with the upper stories of them. Younger than the times of Augustine again, it cannot be, as he certainly could not do without a chapter-house. This chapter-house is now connected with the octagon, or Our Lady's chapel, through an oblique passage, and has no windows to the south; nor, if there, could they have been of any use, as the northern wall of the church is so near that no light could reach them. Originally however, as may be seen from the arches still existing, there were two windows on the south side, symmetrical with those on the north side, which shows abundantly that there was once a larger distance between the southern wall of the chapter-house when these windows existed, and the northern wall of the chancel, than now,—in other words, that the old chancel or church was narrower, and lacked aisles. Furthermore, there are manifest traces of a doorway midways in the southern wall of the chapter-house, while on the contrary the opening to the oblique passage which conducts to the octagon appears to be later than the original arrangement; it follows that the communication between the chapter-house and the church formerly took place through the doorway now spoken of, conducting no doubt to a vaulted passage from the church, which was pulled down and the doorway itself blocked up when the chancel was enlarged by the aisles, and the octagon was annexed. Instead of the former passage the oblique one now existing was then built, from the northern parts of the octagon to that part of the chapter-house where the apse is connected with the rectangle. Also on the western wall the chapter-house appears to have had an entrance, which was probably blocked up at the same time."

Of the extent of the works executed by Augustine beyond the transepts, and those necessarily involved in the attachment of the same to the old church, with the chapter-house, &c. for the use of the chapter, there appears no particular account. Augustine fled to England in 1180, and returning to his see in 1183, died in 1188, having been on a sick bed since the autumn

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of 1187. In the four years between 1183 and 1188, it is probable little more was done than has been previously referred to; and under the five immediate successors of Augustine, viz., Eric, Thorir Gudmundarsson, Gotharm, Peter of Husastad, and Thorir of Throndheim, (1188—1230,) the same seems to have been the case. In 1231 however, succeeded Sigurd Eindridason, who filling the primacy from this date to 1252, the long space of twenty-one years, recommenced and carried on in earnest the work of his predecessor. It is stated in the saga of king Hacon that this prelate had in 1265 laid the foundations of the nave or western part, having, it is probable, necessarily also made such alterations to the then existing buildings and works of Augustine, as became necessary to accommodate the altered plan and different style of his time. From this period the works appear to have been continued regularly more or less, being ultimately completed under archbishop John in 1280.

Arrived at this point then, beyond which the history of Throndheim cathedral is one rather of its vicissitudes than of its further advance, the summary of its architectural progress—if we except the works to the polygonal apse by archbishop Eiliff, before and after the fire which occurred in 1328, and which might be taken as a crowning work—would stand as follows, and exhibit—1. The foundation and building of St. Olaf's church, afterwards incorporated with and used as the choir of the cathedral church; comprising a period of from about 1050 to 1157. 2. The erection of the transepts and their eastern chapels, with the chapter-house, and the attachment of the same to the older church; extending from 1161 to 1180. 3. The commencement of the nave, its progress, and the ultimate main completion of the cathedral; reaching from 1231 to 1280.

Of the older church, or that of St. Olaf, first named, no material part now remains. It is probable, as has been before stated on the authority of the book under notice, that a portion of its structure was associated and incorporated with the after works to the choir. The walls of the aisles and the polygonal eastern apse, subsequently added, yet remain: the character of both the latter is Early Pointed.

The second noticed, viz. the transepts and chapter-house, remain in comparatively perfect state, and exhibit, as previously observed, the Norman or Romanesque character prevalent throughout the north of Europe at the date given.

In regard to the nave, the remains exhibit the Early or First Pointed style, agreeing also with the historical record of their erection. The aisles of the choir, as before said, are also of this style, and the main portions of the apse a mixture of this and somewhat later work. For more detailed information however, as respects all the remaining portions, we would direct the reader to the several plates which form the illustrations to the valuable letterpress of Prof. Munch, of which we have endeavoured to give a brief, and, necessarily so far, very imperfect and inadequate notion. These plates, thirty-one in number, comprise plans, elevations, sections, and perspective views, both of the building as it now appears, and in a perfectly restored form, with details at large, representing in a very complete and effective manner all the architectural peculiarities and characteristics of the edifice.

Of these plates—those numbered 1 and 2, the former the general ground plan, and the latter a transverse section, having been before described—No. 3 gives a perspective view of the remains of the north aisle and lower part of the west front of the nave, viewed from the north-west, very effectively engraved: a portion of the work thirdly mentioned in the summary before given; showing at the same time the north transept and part of the old central tower, the works of Augustine mentioned secondly in the same. Plate 6 is also a perspective view, but more enlarged and from the west, of the remains of the west front. This is a very interesting plate, exhibiting a highly enriched arcaded arrangement of niches and statues, which extending above the three entrances originally admitting to the central portion and its aisles, embraces also the western faces of the two towers, which appear to have anciently projected beyond the line of the aisles and finished this end. The number of the niches comprised in the range is eighteen, and they appear to have formerly contained statues; five are shown as remaining, but more existed it is stated so late as 1661. Over each entrance the arcade is interrupted by an arch, which appears to have been left open as a window for light over each of the side doors, but was occupied by a sculptured representation of the Crucifixion in the centre one.

Plates 4 and 5 are general perspective views of the church, the former from the north-east, the latter from the south-east, exhibiting many points of great interest and value both archæologically and architecturally. In Plate 4 the exterior of the chapter-house, and the north-east view of the north transept with its eastern chapel and north porch, are important features; while in Plate 5 we have the very rich southern entrance (given on a much larger scale in Plate 23), and other points of much interest, as showing the character of the Early Pointed work of the choir. Among these latter may be specially noticed the arcade high up in its eastern wall, and the remains of the corbel table and arches, which were formerly part of its southern clerestory.

Plates 7—13 represent, geometrically, different portions of the transepts, with their chapels, and the north porch of the same, together with enlarged details of the mouldings and other component features. Plate 14 gives a vertical section through the lady-chapel or apse, with plans of its triforium and clerestory, a portion of the former being shown to a larger scale on Plate 15. The architectural details and arrangements as here shown are worthy attentive examination and study. Plates 16 to 20 give details from various parts of the lady-chapel.

Plates 21 and 22 exhibit details from the chapter-house, of which Plate 28 gives an interior perspective view, and at the foot thereof its plan as distinct from its connection with the church: this latter is a very elaborate plate, and is an interesting example of the Norman chapter-house. The circular apse and the passage of communication at this part are very curious. Plate 23 is a perspective view of the south porch and the adjoining bays of the south aisle of the choir, shown in the general view from the south-east, Plate 5. The nature of the decorations originally employed to this feature and the windows of the aisle are very clearly exhibited in this plate. Some beautiful carved detail from this porch is given in Plate 9, figs. A and B, in which cannot fail to be traced the resemblance to the ornamental borders of stained glass seen in Late Norman and Early English work in this country.

Plate 24 gives geometrical elevations of the remaining part of the north face of the north-western tower, and of two compartments of the north aisle of the nave, one of them being that in which the north door of the same is placed. The detail is very clearly made out in the plate, and it shows a very interesting treatment of Early Pointed features. The aisle window is of two conjoined plain lancets, with exterior shafts and a circle above, the hood-mould running round both arches and the circle. The latter has no tracery, agreeing with a similar though larger circular light over the north door. The tower window is cinquefoiled, the upper foil circular, within a recessed pointed arch supported on four shafts, the inner ordinance or face of the arch having a pleasing flowered ornament introduced. Along what is at present the eaves-course of the aisle is an ornamental band, containing a scroll pattern of good design and execution: this band or cornice is given to a larger scale in Plate 27. Plates 25 to 27 are details from the eastern apse or lady-chapel. Fig. 3 in Plate 26 shows a very curious example of a carved capital; and fig. 1 in Plate 27, a very good and boldly relieved scroll ornament applied as a string or cornice.

We have now completed our review of the history and illustrations of Throndheim Cathedral given in the work under consideration, to the extent to which the same are to be taken authoritatively or with reference to the building itself as it now stands. The three next plates of the work represent what it is considered may have been its appearance in a perfect state, if, as it is remarked by the author, "it was ever so thoroughly completed as here represented," and which it would be impossible now exactly to establish. It will be sufficient however to say, that these restored views embrace all the existing remains, and for such parts as no longer appear the authority has been derived therefrom, as well as from careful examination of the scattered indications more or less confirmatory. Plate 29, the first of these three last mentioned, gives a restored ground plan of the whole church. Plate 30 is, in like manner, a restored perspective view of the exterior of the cathedral from the north-east, or from the same point of view as Plate 4, which represents its present state. A comparison of these two plates is very suggestive. Plate 31 is a like restored interior view of the choir, looking east into the lady-chapel. This is a most elaborate plate, executed, as indeed are all the other plates, by J. H. Le Keux in his best manner. The rood screen and what is seen beyond is, it seems, in great part still existing. The effect of this portion seen at the termination of the choir is exceedingly beautiful.

We conclude by drawing attention to the interesting fact to

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the architects of this country, that this noble church was constructed by English architects, or at least by architects taught by Englishmen. "This," says the work, "is evident, as well from the general design as from the details; and it is true not only with regard to the older part of the church, from Augustine's times, where the Anglo-Normanism of the forms is so striking, but also as regards the later parts. Augustine entertained," it continues, "the closest connection with England, whither he repaired when obliged to flee his country; it was therefore to be expected that he sent thither for architects, and that his successors should follow his example." To this we have only to add, with regard to the material employed, which also has reference, though not exclusively, to English practices—that several of the columns in the lady-chapel are of a "blackish kind of marble," and that "for many of the smaller shafts and pillars white marble is used." The material is stated to be "chiefly a coarse talcose schist intermingled with quartz, from quarries still visible not far from the town. The more delicate tracery is formed of softer talcstone.....For the foundations gneiss or some other foliated rock is used; above this, beneath the walls of the nave, there is a layer of bluish grey slate."

ON THE NATURE OF THE ACTION OF FIRED GUNPOWDER.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Mr. LYNALL THOMAS presents his compliments to the Editor of the *Civil Engineer and Architect's Journal*, and begs to make a remark upon the review of a small work intitled 'Rifled Ordnance,' which appeared in the January and February numbers of the Journal.* In the latter number, in which that portion of the book which treats of the initial action of fired gunpowder is reviewed, there is the following observations: "Mr. Thomas seems to think it absurd to suppose that in the same gun the same amount of powder should exert different pressures on the ball, according as the mass of the ball be great or small." A more careful perusal will show that this statement is far from being correct; on the contrary, Mr. Thomas has attempted (page 174) to account for this difference in the pressure. He certainly stated that, supposing the ordinary theory (which assumes that the whole of the powder is ignited before the shot is sensibly moved from its place, and that it then exerts a given and uniform pressure whatever the quantity of powder) be correct, that it would be absurd to suppose that any additional weight in the ball would increase the *initial* pressure, as assumed by all writers on the subject. So far from his theory being "a sad mistake," it has been already found necessary to act upon it in the case of rifled cannon, as recommended by Mr. Thomas to the committee appointed to inquire into it. If the editor would rectify the above error Mr. Thomas would feel obliged.

P.S.—Mr. Thomas has omitted to notice an observation made with respect to the first action of fired gunpowder: he has not supposed a *separate* force, but has wished to show that the first action of the fluid upon the shot is similar to that of a *blow*, and not a pressure; and that the force of this blow differs with the quantity of powder and the form of the containing chamber. Mr. Thomas begs to observe that he has made numerous experiments upon this subject, besides those described in his paper.

9, Union-street, Berkeley-square,
May, 1860.

SIR,—Will you permit me to make a further remark relative to your review of my theory of the initial action of fired gunpowder. In the experiments there proposed, namely, with the wooden tubing, it is quite likely that the tubing might resist the force of the explosion of a given quantity of powder if the gas were allowed to escape freely in one direction, and that it might split if an iron shot were placed upon the aperture. For if the sides of the tubing offered a smaller resistance than the inertia of the shot the gas would escape in that direction; but the initial action of the powder in the direction of the aperture or upon the shot would not be greater or less upon this account, unless the chamber were so long and its sides so weak as to cause it to burst before the powder had time to act in the direction of the shot, with the same force which it would have had had it been allowed to escape freely in that direction.

It is to be remembered that the combustion of the powder in the chamber is gradual, and that its action commences from a *point;* or that if the sides of the containing vessel are weak and the gas be not allowed a free escape, it may burst through the sides of a slight tubing: there need be no greater amount of force to do this than would have been exerted had a shot not been placed upon the aperture, only the action would take place in a different direction. If however the vessel were strong enough to resist the explosion when the shot was placed upon the aperture, there would be no appreciable difference in the initial action of the powder whether the shot were of four or of forty pounds weight. The initial action of the gaseous fluid upon the shot and the sides of the containing chamber will always be of a certain magnitude, according to the form of the chamber, the quantity and quality of the powder, &c., and this initial action cannot be increased by any addition to the weight of the shot—as erroneously supposed by Piobert and others. The *whole* force of the powder may be increased upon the sides of a vessel by completely confining it, or by greatly retarding the expansion, but the first force of the explosion cannot vary with the weight of the shot. When the freed gas first acts upon the shot it is in the manner of a blow, which is given in a time so small as to be inappreciable; and I found that whether the shot were of four or of thirty pounds weight (the charges of powder being equal) they equally acquired a finite velocity in a time so small as to be inappreciable, only their respective velocities were proportional to their weights. If the weight of the shot had any influence on the initial action of the powder, or there had been any appreciable difference in the time of action, the larger shot would have acquired a greater proportional velocity than the smaller, but this was clearly not the case.

The difference between action caused by an explosion and that of an expansion have not been sufficiently considered in this matter; and however difficult it may be to clearly define the distinction between them, still it exists.—I am, &c.,

LYNALL THOMAS.

[WE are sorry that we have misrepresented, though unconsciously, Mr. Thomas's meaning in the passage to which he refers; but in the second of the two letters addressed to us he repeats in substance the statement to which we objected. After observing, with regard to the experiment of the tubing, that what we predicted would probably take place, but only "in obedience to the law that the action of the powder is always in the direction of the least resistance," he goes on to assert, that if the inertia of the shot were increased twentyfold, no additional force would be exerted on it. Now first, if by action of the powder we are to understand the pressure exerted by the gases freed during the combustion of the powder, we distinctly deny that this pressure would be exerted only in the direction of least resistance: we believe that the unit pressure on the interior of a gun-barrel during the motion of the ball is at least equal to that on the ball, which latter pressure is the pressure in the direction of least resistance;—and secondly, we contend that the pressure on the ball in the experiment we proposed will depend on the inertia of the ball,—if it be made of pasteboard the pressure will be less than if it were made of cast-iron.

Again, we repeat our assertion, that a bullet projected from a gun does not instantaneously acquire any finite velocity; that is to say, that it has no initial velocity, and that its velocity is continuous, starting from zero and progressing continually to its maximum value at emergence from the gun. The fact is, there is no instance known of velocity instantaneously acquired, or of initial velocity, in the mathematical sense of the term. If a ball in motion impinge on another at rest, the velocity acquired by the latter and lost by the former is not instantaneous, but is due to a finite, though very great, pressure exerted by the balls upon each other during a finite, though very short, period of time. The displacement of the elements of the balls in contact with each other, as manifested in their mutual compression is the cause of the pressure, which will be greater or less, and be maintained during more or less time, according as the balls are more or less perfectly rigid and inelastic; and in order that the pressure may be infinite and its period of action zero, the balls must be perfectly rigid and inelastic, in which case, no doubt, the velocities generated and destroyed would be initial; but then, experience has not yet made us acquainted with perfectly rigid inelastic bodies, and clearly, such an initial velocity could never be communicated by the pressure of an elastic fluid. But if we

* See *ante*, page 58.

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understand Mr. Thomas's reasoning correctly, he appears to us to think that this initial velocity is not at all due to fluid pressure, as indeed we have just demonstrated that it is impossible it could be. The object of the experiment detailed in his book is, if we rightly apprehend it, to demonstrate that a velocity can be communicated by gunpowder under circumstances when no fluid pressure acts for any finite distance on the projectile; and we in reply endeavoured to show by means of his own experiment slightly modified, that a pressure did exist, and acted for a finite though small space on the ball. To be logical he ought to prove that the gunpowder exerts initially an infinite pressure, for, without such an hypothesis, by no known law of mechanics could an initial velocity be imparted.

The exact theoretical determination of the velocity of a bullet projected from a gun is beyond the power of analysis, even supposing we knew the rate at which the powder burns, and the quantity and temperature of the gases given off. The simpler case of a bullet projected from an air-gun is insoluble if we take into account the *mass* of the compressed air; if we neglect that, in comparison with the mass of the bullet, which will lead to but a very trifling error, the problem is of course easy enough. However, we will give the equations which involve the solution of the problem, when the mass is taken into account, but friction neglected.

Take a straight line AD for the whole length of the barrel, of which AB at one end is the part occupied by the compressed air before the ball begins to move. Let q be any point on AB, at time $t=0$, and let Q be the corresponding point in the barrel at time t, that is to say, the point in the barrel occupied at time t by the air which at time 0 was at q. Let $AQ=x$; $Aq=s$; $AB=a$; p, the pressure at Q; p', the pressure on AB before the ball moves; ρ the density at Q, ρ' of AB at time $t=0$; $p=k\rho$, the law connecting pressure and density; m, the mass of the ball; A, the area of a section of the tube; P, the place of the ball at time t; $AP=x$. Then for the motion at Q we have

$$\rho\frac{d^2x}{dt^2}=-\frac{dp}{dx}=-k\frac{d\rho}{dx}$$

But $A\rho\delta x=A\rho'\delta s$ $\therefore$ $\rho=\rho'\dfrac{ds}{dx}$

$$\therefore\ \frac{d^2x}{dt^2}=-k\frac{\dfrac{d^2s}{dx^2}}{\dfrac{ds}{dx}}=k\frac{\dfrac{d^2x}{ds^2}}{\left(\dfrac{dx}{ds}\right)^2}$$

Together with the conditions

$$\frac{d^2x}{dt^2}\ (s=x)=-\frac{k\rho x}{m}=-\frac{k\rho'}{m}\frac{ds}{dx};\ x=x,\text{ or } s=a;$$

$$\frac{d^2x}{dt^2}=0;\quad s=0.$$

On the other hand, if we neglect the mass of the air, if $AP=x$, v the velocity of the ball, $mv\dfrac{dv}{dx}=k\rho'\dfrac{a}{a+x}$; whence

$$\frac{v^2}{2}=c+k\rho'\frac{a}{m}\log(a+x);$$

and if b be the total length of the barrel, V the final velocity,

$$\frac{V^2}{2}=k\rho'\frac{a}{m}\log e\left(\frac{b}{a}\right)$$

We have given these two little investigations to show how the subject would be treated theoretically. As to the theory of initial velocity, there can be no question at all that that is an erroneous one; and we certainly are surprised that so well-read and clear-reasoning a man as Mr. Thomas continues to maintain it.—Ed.]

THE SOCIETY OF ENGINEERS.

This very excellent society was founded in the year 1854, for the purpose of affording to the junior members of the engineering profession more particularly, and to those engaged in science generally, opportunities for the discussion of engineering and other scientific subjects, and at the same time for affording early in life facilities for professional friendship and assistance. The society consisted at first of only a few members, holding their meetings monthly at the office of one of their number, but such was the increase in the number of members that the accommodation was soon found to be insufficient, and the society engaged one of the committee-rooms in Exeter-hall, London, which for the same reason had to be abandoned for the lower hall, where they at present hold their meetings. The society consists of civil and mechanical engineers practising on their own account, assistants and pupils of engineers and of manufacturers, and others connected directly or indirectly with engineering pursuits. The annual subscription has been purposely fixed very low, namely ten shillings per annum, in order that the sphere of usefulness may be as large as possible. During the first year the number of members amounted to twenty, the average attendance at each meeting being twelve; the number of members has now increased to nearly two hundred, and the average attendance is above one hundred. The subjects already discussed embrace railways, water works, gas works, dry and wet docks, harbours, and river improvements, irrigation, electric telegraph machinery.

We heartily wish the society all that continued and increasing prosperity to which its very useful aims justly entitle it; and trust, that as the success and value of such a society depend entirely upon the well sustained personal efforts of its members individually, there will be no lack of interest on their part, and that papers on practical engineering subjects will be constantly contributed. There is abundant room for such a society, and having made so good a beginning, if it be well sustained it will soon secure the extended support and co-operation of the profession.

COLONIAL PATENT LAW.

By F. W. Campin, F.S.A.

(*Continued from page* 156.)

The evils connected with our existing British patent laws are most apparent in their operation in the colonies; the expenses and difficulty to which the inventor is subjected being increased by the complications consequent upon the official channels of communication with the colonies. The patent laws for India and Ceylon are distinct, although the one is almost a copy of the other. Double fees, agency, professional charges, and trouble are consequently imposed upon the patentee.

India.—The law of 1859, for granting exclusive privileges to inventors, is succinctly this:—Sections 1, 2, 3, the inventor may petition for leave to file a specification of his invention, whereupon an order in council granting this leave may be made: although, first of all, this petition may be referred to some official for inquiry and report. 4. Petitioner, having filed his specification, is entitled to the exclusive privilege of proprietorship of his invention for fourteen years from the time of filing specification, which filing must be effected within six months from the date of the order. The fourteen years may be hereafter further extended in peculiar cases. 5. The order to file specification may be made subject to special conditions. 6. Specification to be in writing, and describe the invention. 7. Petition and specification to be left with the secretary to government, which petition must be accompanied by a declaration, the date of delivery whereof to be endorsed on the petition. 8. False statements in declaration to be punishable as perjury. 9. Specification not to be filed before payment of fees. 10. Copies of specification to be delivered to the secretariats of Bengal, Fort St. George, Bombay, and the North-Western provinces; which copies are to be open to public inspection upon payment of a fee of one rupee. 11 and 12. Petitions and specifications to be registered. 14. Petitioner may in some cases apply for leave to file an amended specification. 15. No person to be intitled to the exclusive proprietorship in any of the following cases.—If invention is not new; or if petitioner is not the inventor; or if the specification does not describe the invention; or if the petition or specification contain fraudulent mis-statements. 16. Exclusive privilege to cease if government declare it mischievous to the public; or if the government upon breach of any special condition proved declare that it shall cease. 17. Importer of invention if not the actual inventor not to be deemed the inventor. 18. But a foreigner whether resident abroad or not is not debarred from taking advantage of this law. 19. This section states that "an invention shall be deemed a new invention if it shall not before the time of applying for leave to file the specification have been publicly used in India or in any part of Great Britain and Ireland, or been made publicly known in any part of India or of the United

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Kingdom by means of a publication either printed or written or partly printed and partly written. The public use or knowledge of an invention prior to the application for leave to file a specification shall not be deemed a public use or knowledge within the meaning of this section if the knowledge shall have been obtained surreptitiously or in fraud of the inventor, or shall have been communicated to the public in fraud of the inventor or in breach of confidence, provided the inventor shall within six calendar months after the commencement of such public use apply for leave to file his specification, and shall not previously have acquiesced in such public use; provided also that the use of an invention in public by the inventor thereof, or by his servants or agents or by any other person by his license in writing for a period not exceeding one year prior to the date of his petition shall not be deemed a public use thereof within the meaning of this act." 20. "If an inventor who, prior to the time of applying for leave to file a specification of an invention under this act, shall have obtained Her Majesty's letters patent for the exclusive use of such invention in the United Kingdom or any part thereof, shall within twelve calendar months from the passing of this act, or within twelve calendar months from the date of such letters patent, petition the governor-general of India in council for leave to file a specification of such invention (which petition shall be in writing in the form or to the effect mentioned in the schedule) the invention shall be deemed a new invention within the meaning of this act, if it was not publicly known or used in India at or before the date of the petition of such letters patent, notwithstanding it may have been publicly known or used in some part of the United Kingdom or in India before the time of his petitioning under this act for leave to file the specification; provided the petition for leave to file the specification shall state that such letters patent have been granted, and shall also state the date thereof and the term during which the same are to continue in force; provided also that an exclusive privilege obtained under the provisions of this act by an inventor who has obtained Her Majesty's letters patent for the exclusive use of such invention, shall cease to have effect if such letters patent be revoked or cancelled, and that no such exclusive privilege shall extend beyond the term granted by such letters patent, unless the same be renewed, in which case the exclusive privilege may be renewed under this act for the extended term or any part thereof." 22, 23. An action for infringement may be maintained; and a defect in the specification or petition, or want of novelty in the invention not allowed to be a defence to the action for infringement, but the use of an invention in India or the United Kingdom before date of petition, by the defendant or some person he represents, a good defence to such action. 24. Application may be made to the supreme courts to declare that there is no valid exclusive privilege on the following grounds:—invention of no utility; invention not new; petitioner not the inventor; invention not described in specification; fraud in the petition or specification; fraudulent mis-statement in petition or specification; insufficient description of part of the invention in the specification. 25. Like application may be made as to part of an invention. 26. The advocate-general may proceed on breach of special condition. 27 and 28. Supreme court may direct issue for trial to other courts and new trials may be allowed. 29. As to judgments and costs. 30. Specification may in certain cases be amended by court. 31. Mis-statement in the petition, if not fraudulent, not to defeat the privilege. 32. Entry in registry-book of any judgment, &c. declaring the privilege to be void. 33. Actual inventor, if he applies for an assignment within two years of the date of any petition to file specification, entitled to assignment of any exclusive privilege fraudulently obtained. 34. Particulars required to be delivered in action for infringements. 35. As to service of proceedings. 36. Transitory provisions and interpretations, &c. 37. Stamp on petition, 100 rupees. Final clauses.

Ceylon.—The law of patents in Ceylon, passed 2nd Nov. 1859, is a modified transcript of that for India. It enacts that any person, being the inventor or importer of an invention through the forms annexed to the act, using the terms inventor, importer or owner, may petition for leave to file a specification, when similar official proceedings will have to be gone through as in India, the principal difference being that in Ceylon the British patentee has to file a specification and an exemplification of the letters patent granted to him; whereupon he is intitled to the patent right or exclusive privilege for Ceylon for fourteen years, and there are no words in the Ceylon act limiting the term within which the British patentee must apply for the patent right as in India. In the case of the invention not being patentee's the specification has to be filed within six months from the date of the order in council, and when the filing is effected the governor in executive council may make the necessary grant under the public seal of Ceylon. A stamp duty of £10 is fixed on every petition for leave to file a specification.

INVENTIONS RECENTLY PATENTED.

MANUFACTURE OF IRON.

F. Levick, Coalbrook Vale Iron Works, *Patentee*, Oct. 14, 1859.

This invention consists of the method of applying to the manufacture of iron the gases or mixture of gases produced by passing steam over coke or other carbonaceous matter sufficiently heated to effect the complete decomposition of the steam. The gases or mixture of gases consist of hydrogen and carbonic oxide, and in using them the patentee either employs the mixture by itself or mixes or uses in conjunction with it the gas evolved from the blast or iron smelting furnace, which gas from the blast furnace consists mainly of nitrogen and carbonic oxide. Instead of the gas evolved from the blast furnace, the mixture of nitrogen and carbonic oxide obtained by passing atmospheric air over incandescent carbonaceous fuel is sometimes substituted. The mixture of hydrogen and carbonic oxide is applied to the processes of refining pig iron, of puddling either pig or refined iron, and to the balling or reheating of iron. The patentee also applies the gaseous mixture to iron remelted in a cupola, or at any stage of the manufacture of iron between the smelting process and the conversion of the cast-iron produced by the smelting process into wrought or malleable iron. In all cases the inventor uses either the gaseous mixture of hydrogen and carbonic oxide produced by passing steam over incandescent carbonaceous matter by itself, or that mixture in conjunction with the gases evolved from blast furnaces, or obtained by passing atmospheric air over incandescent carbonaceous matter.

The patentee uses the expression "gaseous mixture" to indicate either the mixture of hydrogen and carbonic oxide used alone, or used in connection with the gases evolved from blast furnaces, or obtained by passing atmospheric air over incandescent carbonaceous matter.

In applying the invention to the puddling of iron or to puddling furnaces, or to other reverberatory furnaces used in the conversion of cast-iron into wrought or malleable iron, such as balling and reheating furnaces, the gaseous mixture is introduced at or near the bridge of the furnace, and on the fire side of the bridge, the gaseous mixture being introduced in jets by metallic pipes or passed through a slit or opening in or near the bridge.

The patentee states that his invention is applicable to puddling furnaces in which coal gas or other gaseous fuel is employed, as well as to puddling furnaces in which solid fuel is employed.

In applying this invention to the refining and remelting of iron, or to such furnaces as the refinery and the cupola, it is preferable to introduce the gaseous mixture in a jet or jets delivered at or near the point where the blast of air is delivered by the tuyeres that are at that part of the furnace where the combustion is most intense.

The decomposition of the steam is effected by passing steam from a steam boiler or generator through a retort or closed vessel containing coke or other carbonaceous matter, the retort or vessel being situated in a furnace by which it is heated to bright redness. The steam is decomposed by passing over the heated carbon, and a mixture of hydrogen and carbonic oxide is produced, which is conducted by pipes to the furnace in which it is to be used. It is preferable to superheat the steam before passing it over the heated carbonaceous matter. When coke or carbonaceous matter containing sulphur is employed to decompose the steam, the gases produced may contain a small quantity of sulphuretted hydrogen. In such cases the gases are purified by passing them through water containing lime, either dissolved or suspended therein, or through slaked lime or hydrated oxide of iron.

The patentee does not explain the method by which the gases from the blast furnace may be collected, as many methods of collecting them are known and commonly practised.

Claim.—The application of the gaseous mixture obtained by

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passing steam over heated coke or other carbonaceous matter to the puddling or refining of iron, or to iron reheated or melted in a cupola, or to iron in any stage between the smelting and the complete conversion of the cast-iron into wrought or malleable iron, whether the said gaseous mixture obtained by passing steam over heated carbonaceous matter be used alone or in conjunction with the gases evolved from the blast or smelting furnace or produced by passing atmospheric air over incandescent charcoal or other carbonaceous matter.

AXLES FOR RAILWAY AND OTHER CARRIAGES.

J. L. Tenting, Paris, *Patentee*, October 11, 1859.

The patentee describes this invention as consisting in the employment, in addition to the ordinary axle of railway and other carriages, of a hollow axle, serving as an envelope or casing thereto, rendering the two wheels of an axle independent of each other, that is to say, each wheel able to turn according to requirement, and with facility in curves, whatever their radius, and without friction on the rails, thereby effecting, firstly, a great decrease in the tractive force required; secondly, a diminution, if not the annihilation of the chance of rupture of the axles, which by this arrangement are no longer subject to be twisted; thirdly, avoiding almost entirely the running of carriages off the rails, resulting from the rigidity of the wheels as at present set up. The patentee states that with this system of axles railroads may be constructed with curves of a small radius, which could not be effected until now without danger.

A hollow axle, made of iron or other material of sufficient strength, serves as an envelope or casing to the ordinary axle. Upon this hollow axle is fixed one of the two wheels of the carriage, and the other wheel is fixed to the ordinary axle. The hollow axle should be bored smoothly inside to permit the ordinary axle, the surface of which is truly turned, to work within it freely. The hollow axle may be of the same length as the distance between the outside of the nave of one wheel and the inside of the nave of the other wheel, but this length may be modified according to requirement. The ordinary solid axle alone supports the carriage, which arrangement has the advantage of not rendering any alteration necessary in the present construction of carriages, and by which their strength is considerably increased. In case this ordinary solid axle should break, no accident will occur, as the hollow axle which envelopes it will keep it in its place, and will allow it to continue the journey without any dangerous result. Both axles must be lubricated.

Claim.—The application to railway and other carriages of a hollow axle, serving as an envelope or casing to an ordinary axle.

APPARATUS FOR GENERATING STEAM.

W. E. Newton, London, *Patentee*, October 4, 1859.

The object of this invention is to generate steam with a very small consumption of fuel by means of a portable apparatus, and intermittingly, in such quantities as are required for immediate use, thereby dispensing with the use of large reservoirs either for steam or water, and preventing accidents resulting from the explosion of steam generators.

A fire chamber forms the lower part of a chamber which is divided horizontally into two parts; the lower part, the walls of which may be of metal or masonry, forms the fire-place where the grate is situated. In the upper part of this chamber is a steam chest, and directly over the steam chest is a water chamber, and above this water chamber there is an air chamber. The steam chest and water and air chambers may be of cast or wrought metal. A coil pipe is placed within the fire chamber, and the upper end of this coil communicates with the water chamber, and its lower end is attached to a force pump. A vertical tube passes down through the air chamber into the water chamber, and is provided with a loaded valve at its upper end. To the bottom of the steam chest there are bolted a series of inverted cone-shaped tubes, which extend down over the fire. Inside the steam chest are placed a series of perforated vertical tubes, which extend down within the cone-shaped tubes. The upper ends of the perforated tubes pass through the top plate of the steam chest, and are made flush with it, the tubes being open at their upper ends, and perforated at their lower parts. An eduction pipe leads from the steam chest, and is provided with a safety-valve. Within the water chamber is placed a circular disc, which is directly over the top of the steam chest, and is attached to the lower end of a vertical shaft, which passes up through the water and air chambers, and is connected in any suitable way to the engine, so as to cause the disc to be partially rotated in a reciprocating way. This disc is perforated with holes, the diameter of which is equal to that of the perforated vertical tubes, the holes being also in circles concentric with those in which the vertical tubes are placed. The air chamber is supplied with air through a pipe; a vertical tube which communicates with the top of the chamber has a loaded valve at its upper end. A tube leads from the air chamber through the steam chest into the space between the reciprocating disc and the top of the steam chest; this tube is provided with a valve which is operated automatically by the same mechanism which works the disc. A damper is placed in the fire chamber directly over the fire for the purpose of regulating the heat in the upper part of the fire chambers.

The operation is as follows:—Water is ejected through the coil pipe into the water chamber, and is heated during its passage through the fire chamber. The disc having a reciprocating partially rotating movement, is so arranged that its holes will register with the orifices of the perforated vertical tubes at the termination of each stroke or movement, and when the holes in the disc and the open ends of the tubes register or coincide, water will be forced down the tubes with a force or pressure due to the pressure of the water in the water chamber. This pressure is regulated by adjusting the weight on the lever of the valve. The water issues in fine jets through the perforations in the lower parts of the tubes, and is forced in spray form against the hot cone-shaped tubes, and is immediately converted into steam, which fills the steam chest, and is conveyed by a pipe to the engine or place designed for its use. The volume of steam generated at each stroke or movement of the disc will of course depend upon the amount of water that is forced out of the tubes during the time the holes and tubes are in register, and this amount is governed by the pressure in the water chamber, which may be regulated, as before stated, by adjusting the weight of the valve, the surplus water being ejected through the valve.

Air is forced into the air chamber through the pipe, and the pressure of air in the chamber is regulated by adjusting the weight of the valve. A reciprocating valve is opened and closed automatically by the engine the same as the disc, and each time the holes in the disc register or coincide with the tubes, the valve may be opened so as to allow a certain quantity of air to infuse itself with the water as it passes down into the perforated tubes. This air, however, may be admitted at the same time before or after the water feed; and the supply of water and air may be controlled in equal or unequal proportions as experience may dictate, in order to facilitate or expedite the conversion of the water into steam.

When the apparatus is not in use the damper is closed, in order to prevent the burning of the tubes.

Claims.—1. The employment or use of the steam chest, provided with tubes, and placed directly over the fire chamber, and provided with the perforated water tubes, communicating intermittingly with water, under pressure in the chamber.

2. In connection with the steam chest and tubes, the use of the air chamber, provided with a pipe, and valve or any equivalent means for mixing atmospheric air with water as the latter is converted into steam.

3. The employment or use of the reciprocating perforated disc, or any equivalent contrivance for regulating the admission of water from the water chamber into the steam chest.

4. The use of the damper in the chamber, and the door, in connection with the dampers, in the pipes, in combination with the steam chest, the cone-shaped tubes, the water tubes, and water chamber.

COATING METALLIC CONDUCTORS FOR ELECTRIC TELEGRAPHS.

J. Macintosh, London, *Patentee*, October 5, 1859.

This invention proposes to effect improvements in coating metallic conductors for electric telegraphs. For these purposes lampblack, napthaline, and gutta-percha are combined into a plastic compound, and applied to wire or other forms of metal conductors in like manner to that in which gutta-percha is now used: but it is preferred to employ such compound as an external coating to gutta-percha, or other insulating coating or coatings. In some cases a compound of india-rubber is employed, or india-rubber and gutta-percha combined with lampblack, in pre-

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paring compounds for coating metallic conductors for electric telegraph purposes.

In preparing a composition and applying it the patentee uses at the rate of about fifty parts by weight of gutta-percha, twenty-five parts by weight of napthaline, and twenty-five parts by weight of lamp-black, though other proportions may be used. He applies heat, about 170° Fahr. to the napthaline, which melts it, and introduces and mixes therewith the gutta-percha; the heat and the fluid napthaline dissolve the gutta-percha. The fluid compound is run off from the impurities, and then mixed with the lampblack, and the compound is then used as a coating material in the ordinary manner, preference being given to its employment as an outer coating on a previous coating or coatings of gutta-percha or other insulating material. When the materials are pure they may be mixed by masticating machinery, as when mixing gutta-percha with other materials. In some cases lampblack is combined with india-rubber for external coatings on insulated wires or electric conductors, and as much lampblack is used with the india-rubber as the india-rubber will take, and yet retain a plasticity such as will enable it to be applied by rollers, or by being forced through dies as a coating to a previously insulated or coated wire or other electric conductor; or in place of india-rubber being used alone, gutta-percha may be combined therewith.

ON THE TREATMENT OF SUBSERVIENT FEATURES AND ACCESSORIES EXHIBITED IN SOME LATELY ERECTED BUILDINGS.

My former communication, Mr. Editor, on the above subject, as you will perceive on reference to your number for March last, concluded with the observation, that there were two or three other points in reference to the Clergy-house at Bayswater which I could not refrain from remarking upon. The first of the points above alluded to has relation to the mode in which the water from the gutters is brought down the street front; and the other, to the way in which the staircase turret is finished. The front span of the roof is gabled in two gables, to receive a like number of lancet windows of three lights each, the centre one carried up above the others; and between these is a chimney stack rising to some height, and finishing in stunted octagon shafts. This chimney stack is corbelled out—by the way, with a very unsightly arrangement of brick projecting courses—at the level of the second story, or that next but one below the library, and it projects about 18 inches from the face of the main wall. At the level of the gutter in the roof, or valley between the gables, this shaft is pierced through for the passage of the water to the cistern-head of, *mirabile dictu!* a common six-inch cast-iron rain pipe, with the ordinary iron tacks, &c. Standing in advance of the plane of the wall below and elsewhere, this pipe empties itself into a stone bracket or gurgoyle projection of the lower cornice, by which the water from it is conducted to other lengths of cast-iron, and so into the ground. Of all places, the centre and solid of a chimney shaft seems to strike an observer at once, and naturally, as the most improper for an accessory of this kind. It is true that to the initiated it is known that the flues pass on each side; but surely, a position less open to question might have been found. Either interior angle of the projection would have received and accommodated it less offensively; while means might surely have been forthcoming for a more fitting and characteristic one than the everyday round iron pipe, and its universal, though certainly not catholic head.

The staircase turret, the next point, would seem to profess to be an imitation of the French *tourelle*. A prevailing treatment, or rather feature, of these interesting adjuncts of the French houses, is that they rise usually more or less considerably above the wall of the building to which they are attached. At Bayswater the roof of the turret starts from the foot of the adjoining gable, or from the general eaves, so that no part of its walls exceeds the height of those of the main building itself. It is roofed in fact at the same level. This has a very unsatisfactory effect, and destroys the correct appearance of it as a tourelle or turret, reducing it to a simple angle termination. It has also the disadvantage of causing no break in the sky-line except what the upper part of the terminating pinnacle affords, its roof being backed by that of the main edifice, with which it is all of one tone. Speaking of this pinnacle, which appears to be based upon, if not actually a continuation of, the newel of the staircase, it is altogether a dreadfully ugly affair. These pinnacles, or *girouettes*, are generally very well designed and effective terminations of the French tourelles, &c.; and though, perhaps, in this instance the architect may not have had at command the necessary funds to indulge in the very ornamental character which distinguishes most of them, it would surely have been practicable to have introduced at least a family likeness, and which, though ever so plain an one, would have established relationship and propriety. The one erected is cut of all proportion, and altogether opposed in character—if it can be said, architecturally speaking, to have any—to the profession which the detail of the building elsewhere makes. It is a pity the arrangements of the upper part of this turret have not been more considered. Greater altitude, so that its upper story with the lights which occupy its angular faces should have stood perfectly free and in relief of the main roof behind, and a consequent lifting of its conical roof above the line of the ridge of the former, would have been a great improvement upon the plan followed, and one certainly more in accordance with structures the general arrangement and character of which the building proposes to exhibit.

One other observation in relation to this building will conclude my remarks thereon. In my first letter I alluded to the introduction of the ordinary square sash glazing of some of the windows. The majority of those which light the rooms, &c. from the inner court appear to be glazed in this way, and the treatment of the window openings themselves is of a very common and unartistic kind. They are essentially modern house windows, and approach far too closely, viewed in connection with the treatment of the principal front and other more usually seen portions, upon an exhibition of the practice so keenly satirised by Pugin, and on all occasions so strongly to be deprecated,—that of considering all parts of a building as not equally calling for the admission of a relatively consistent and corresponding character. The show-front system now no longer generally obtains, as indeed the architect of the Presbytery has himself, on more than one occasion, sought to inculcate, as well as practically established. It is to be regretted that in this instance he has disregarded his acknowledged maxim, and departed from his better and more usual custom.—I am, &c.

Censor.

EXAMINATIONS FOR THE ARCHITECTURAL PROFESSION.

In our Journal for April last we made some observations upon the proposed examinations and diplomas for the architectural profession, that subject having been under the consideration of the council of the Royal Institute of British Architects. Since then the council have taken the important step of laying before the members of the Institute a document embodying a preliminary outline of a scheme which they propose for such examinations, to be at present voluntary, but the ultimate result of which should be, in their opinion, the establishment of a system of compulsory examination, extending to all architects, whether members or not of the Institute. We subjoin a copy of the circular issued by the council, and in our next shall make some further remarks upon this very important subject.

"It has now become an established rule, both with the government authorities and with the heads of the learned professions, that candidates either for admission into any branch of the public service, civil, naval, and military, or for participation in the rights and privileges enjoyed by the several denominations of private professional men, should undergo an examination to test their capability to discharge the duties of the positions they may desire to occupy. In divinity and in medicine this rule is of long standing, but the application of it to the branches of the legal profession is comparatively recent.

So far in the public interest has this spirit of affording a guarantee of capacity been carried, that the Universities of Oxford and Cambridge now periodically offer in their 'voluntary middle-class examinations,' to numbers not graduates about to enter on commercial or other ordinary avocations, the means of obtaining a certificate of their progress in the usual branches of modern education. Cognizant of these facts, the Council of this Institute have felt the imperative necessity that the architectural profession should no longer continue the only one open to be assumed, at any rate nominally, with all its heavy responsibilities, by the mere ignorant though bold pretender. It is with this feeling they have taken into consideration a scheme which has been laid before them, for establishing an architectural examination, of which they now submit an outline for the consideration of the members of this Institute.

The question of instituting such an examination has already been dis-

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cussed at meetings of this Institute; and the council do not profess to do more than recommend the initiation of a scheme to be cautiously and gradually developed and brought into working order, in which too much should not be attempted at the onset, but of which, in accordance with the rule now established in other professions, the ultimate result should in their opinion be the establishment of a system of compulsory examination, extended to all architects, whether members or not of this Institute.

Should the scheme be carried into operation and meet with the desired success, some alteration in the rules which now govern the admission of fellows and associates would become necessary.

The council submit the outline of the scheme in the form of propositions, adopted after due consideration by themselves, aided by the valuable advice of the Board of Examiners of candidates under the Metropolitan Building Act, and of the Professor of Architecture at University College, London.

Proposition 1.—That it is desirable to afford an opportunity for a voluntary professional examination to the present associates and to the future fellows and associates of the Royal Institute of British Architects. That an elementary examination be therefore established for the students and associates of this Institute under the age of twenty-five years, and a higher examination in the theory and practice of the profession for associates above that age, and for future fellows.

Proposition 2.—That the rules as to students and their prizes be reconsidered by the council, so as to lead educationally towards the last-named more important examination.

Proposition 3.—That the elementary examination embrace pure and applied mathematics, land surveying, mensuration, geology, ordinary construction and materials, drawing, the styles of architecture, the history of architecture, languages, and chemistry. The examiners to define the subjects absolutely necessary, the marks to be apportioned to each, and the aggregate number essential to entitle each candidate to a certificate.

Proposition 4.—That the chief subjects for the higher examination be such as occur in professional practice, with the general theories on which the detail of such practice is based:—*e.g.*, languages, architectural jurisprudence, the Building Act, sanitary requirements, the history of architecture, the theory of the beautiful, the analysis of the styles of art, architectural composition, the literature of architecture; the theory of the higher subjects of construction, *e.g.*, arches, bridges, and domes, the application of iron, &c. That the subjects for the higher examination may also be a development of those enumerated for the elementary examination, to an extent commensurate with the information on other subjects expected from the person examined.

Proposition 5.—That a curriculum be prepared and circulated, giving a general outline of subjects for examination.

Proposition 6.—That the examiners be authorised to take into consideration any diplomas or certificates of competency that may have been obtained elsewhere, *e.g.*, from the universities of Oxford and Cambridge, the Professors of Architecture at University College and King's College, London.

Proposition 7.—That the examinations be carried on by means of writing as well as orally, and that they take place in the months of July and October.

Proposition 8.—That the examiners be chosen by the president, vice-presidents, the past vice-presidents and the council for the time being, from among the members of the Royal Institute of British Architects, so far as may be possible; and that they receive fees for their attendance.

Proposition 9.—That the following fees be paid by the candidates on entering their names for examination, viz.—for the elementary examination, two guineas; higher examination, three guineas."

NOTES OF THE MONTH.

Institution of Civil Engineers.—The annual *conversazione* given by the president of the Institution of Civil Engineers, will take place on Tuesday, the 5th instant, instead of the 29th May, as at one time intended.

Royal Institute of British Architects.—At the annual general meeting, held on the 7th ult., the following office bearers were elected for the ensuing year:—*President:* C. R. Cockerell, R.A. *Vice-Presidents:* T. L. Donaldson, G. Godwin, M. Digby Wyatt. *Honorary Secretaries:* T. Hayter Lewis, James Bell. *Honorary Secretary for foreign Correspondence:* Francis Cramer Penrose. *Ordinary Members of Council:* B. Ferrey, F. J. Francis, W. Haywood, G. Morgan, C. C. Nelson, J. Norton, F. W. Porter, R. L. Roumieu, J. H. Stevens, G. Vulliamy. *Treasurer:* Sir W. R. Farquhar, Bart. *Honorary Solicitor:* W. Leverton Donaldson. *Auditors:* J. J. Scoles, Fellow, J. T. Christopher, Associate. *Examiners appointed under section* 33 *Metropolitan Building Act*, 1855: The Vice-Presidents and the two Honorary Secretaries, with Messrs. Cole, Fowler, Gibson, Jennings, Hesketh, C. C. Nelson, J. W. Papworth, Pennethorne, Penrose, Scoles, S. Smirke, and Whichcord, Fellows.

The International Exhibition of 1862.—The council of the Society of Arts announce that the sum of £265,750, which was the minimum fixed for insuring the Exhibition, has been guaranteed.

Society of Antiquaries.—At the meeting held on the 3rd ult., the appointment of Mr. Tite, M.P., the new vice-president, was read. Two very beautifully enamelled Georges, and a silver enamelled mace of a Garter king-at-arms, conjectured to be of the time of Charles I., were exhibited by Mr. Franks, who remarked upon them. The Rev. T. Hugo exhibited a Celtic bronze sword-blade of the usual leaf-shape, well preserved, recently found in the Thames. A paper was read by Mr. Akerman, the secretary,—"Notes on the origin and history of the bayonet." A number of specimens were exhibited, extending from the plug bayonet of James II. and William III. to the most modern forms.

The Literary and Philosophical Society.—At a recent meeting Mr. William Fairbairn, F.R.S., exhibited two large pans of cast-iron, procured by Mr. Worthington from China, where they are used for boiling rice. The metal, which was at the strongest part only one-tenth of an inch in thickness, possessed considerable malleability. The president remarked that the art of making such large castings of thin metal was unknown in England.—Mr. F. Gisborne, the original projector of the Atlantic telegraph, in reply to some questions relative to the proposed telegraph to connect Great Britain with America, by using Iceland, Greenland, and Labrador as intermediate stations, said that the fears which had been expressed that the cable would be destroyed on the coast of Labrador by grounded icebergs were not warranted. He was intimately acquainted with the locality, and although there was an immense number of icebergs which grounded on the coast, some, as he had himself observed, in seventy fathoms water, yet, as at Newfoundland, there were inlets with water in the middle of sufficient depth to secure the cable from injury.—A paper was also read by Mr. John Graham, "On the history of invention as applied to the dyeing and printing of fabrics: Part 2nd, Mechanics." The author gave a full account of inventions in printing from the earliest period, of which the following is a brief abstract. The first mention of the application of machinery for the purpose of printing is contained in a grant of patent rights to Arnold Rotespan, in the year 1634, for "a certain pressinge or printinge engine with wheels and rolls, after his peculiar manner." The next great step in advance was the introduction of a printing machine by William Keen and Moses Platt. This machine, which was patented in 1743, consists of three "bowls" mounted on a frame, one behind the other. Over each bowl is placed an engraved printing roller, and above the rollers are placed feeding rollers for the colour, which by their accuracy of fit and weight act also as "doctors." In 1783, Thomas Bell laid the foundation of cylinder printing, in which a most important improvement was effected in 1796 by William Paul of Manchester, by the introduction of the adjusting wheel, now called the "box wheel." In 1806, Joseph Bramah invented his composite roller, by which the designs which are engraved upon it may be transposed at pleasure, and by which several colours may be printed by one roller.

Ordnance Survey.—The report of the Topographical Department has been presented to parliament. The publication of the one-inch maps is nearly completed; the six-inch maps are much less advanced. With regard to the larger scale of twenty-five inches to a mile, there still remains three-fourths of England to be surveyed, a preference having been given to Ireland and Scotland; but it is strongly recommended that this great work be completed. The cost of completing it would not exceed £1,450,000, and would probably be less. "The principal Lines of Levelling in England and in Scotland" will be published this year, and will close the great trigonometrical operations of the survey, which commenced under General Roy in 1784. This department is gradually collecting the most perfect set of maps of every part of the world. It is executing plans of the barracks and forts of this kingdom, and plans of different colonies. Among its publications are a map of Europe, showing the position and produce of the coalfields, and the dependence of the several states upon each other for its supply; plans of Peninsular battles, and plans in illustration of the late Italian campaign, copies of which have been sent to the headquarters of every regiment, to enable the officers to study the tactics of the armies then engaged. The report gives a curious fac-simile of an ancient manuscript copied by photo-zincography, to show the mode of producing perfectly accurate copies of the Ordnance plans.

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St. Patrick's Cathedral, Dublin.—£20,000 has been placed at the disposal of the Dean and Chapter of this ancient cathedral, by Mr. Benjamin Lee Guinness, of Dublin, for the purpose of its restoration. St. Patrick's Cathedral, although in a very neglected state, has many very beautiful remains of the Early English period of Gothic art.

Unsuspected Sources of Lead Poisoning.—A letter appears in the *Lancet*, written by Dr. Hassall, on "Unsuspected Sources of Lead Poisoning." In the course of his observations Dr. Hassall says:—"The whole subject of lead poisoning is one of the greatest importance, and it behoves the public to be thoroughly on its guard against this source of danger to health. For the employment of leaden vessels and pipes, in nine cases out of ten, no absolute necessity whatever exists, and in certain cases they ought, for the better protection of the public health, to be entirely prohibited. From the number of samples of water which I have received containing lead, I am induced to believe that metal is more frequently introduced into the system in this way than is commonly suspected; indeed, so many well-ascertained cases of lead poisoning arising from the use of water contaminated with it have occurred, that I am of opinion that the use of lead for the storage and conveyance of water ought to be entirely discarded, especially in the cases of small towns and single houses. Now this may be readily done by the use of slate cisterns for the storage, and gutta-percha tubing for the conveyance, of water. By means of Chatterton's very ingenious invention, an outer coating of lead is drawn over the pipe without any application of heat, the gutta-percha being quite uninjured."

Astronomical Progress.—The annual report of the council of the Royal Astronomical Society has been recently issued: it states that in the ordinary operations of the Royal Observatory, Greenwich, very little change has taken place since the preceding year. The observations are precisely of the same character as before, and the reductions have been made to keep pace with the observations. The volume of Observations for 1858 has been very nearly passed through the press, and will be ready for publication in a short time: the printing of the volume for 1859 has commenced. The galvanic operations ot the Observatory have been carried on without material alteration; but considerable difficulty has been experienced in keeping up the time communication along the lines of railway and for the drop of the Deal ball, on account of the bad state of the wires leading from the Observatory to the Lewisham station of the North Kent Railway. These wires pass underground, and the difficulty of examining and repairing them is found to be so great, that preparations are being made for carrying another set above ground, across the park and through the town, to the station of the Greenwich Railway. It has been the custom at the Royal Observatory, since the year 1835, at the end of every sixth year to collect the results of the observations of stars and of the sun during the preceding period of six years, and thus to form a new and independent star catalogue, with independent places of equinox. The fourth of these six-yearly periods expires with the year 1859, but as there is reason to think that in the course of another year the observations necessary for forming a complete catalogue of stars of the fifth magnitude visible at Greenwich may be finished, the astronomer royal has decided to defer the preparation of the new or seven-year catalogue to the close of the year 1860. The printing of the Reduction of the Greenwich Lunar Observations from 1831 to 1851 (in continuation of the Reductions from 1750 to 1830, and on the same general system of calculations and the same elements of tables, as far as circumstances permitted) is now advancing. The principal object in these reductions was, to deliver the annual results of the Greenwich observations from the petty inconsistencies which had crept in by reason of the uncertainty on the elements and the theory of the moon's parallax (an uncertainty from which we are at last delivered by the researches of Prof. Adams), and from the small uncertainty on the equinox; and to compare these with a lunar theory more legitimate in its form than that of Burckhardt's Tables. Every observation for a period of one hundred and two years is now computed by the same elements of reduction, and compared with the same tabular elements. It will not be necessary to continue these reductions beyond 1851, as the parallax may be considered as established, and as Hansen's Tables are now applicable (and partly applied) to the years commencing with 1852. In the course of printing some small errors of computation have been discovered; and these will affect in an inappreciable degree the numerical corrections of lunar elements given in the supplemental 'Monthly Notice' for 1859. During the last year several computers have been employed on the principal reductions of the magnetical observations made at the Royal Observatory from 1848 to 1857. They are based entirely upon the photographic registration of the positions of the three magnetometers; and will present, it is believed, the first example of reductions so made. The measures taken for every hour are not the ordinates of the photographic curves, but the ordinates of pencil curves traced by hand as representing the general sweep of the curves, suppressing inequalities of very short period. It is hoped that in this way results of considerable value may be obtained. The ordinates have been taken both for solar hours and for lunar hours, and are so classified as to present, on both systems, the monthly means for days and for hours. The calculations are now far advanced. The Great Equatorial at the Royal Observatory will, it is anticipated, be shortly ready for use. Much delay has arisen from the tardiness of experiments on the instrument and its driving clock, from the personal occupation of the astronomer royal on public business not connected with the Observatory, from the pressure of other business on the opticians; and finally, from little errors of measure derived from the German opticians. It is expected however that the whole will soon be in a state fitted for active employment.

COMPETITIONS.

Designs are invited for school buildings at York, capable of containing 100 boys, with master's house, and a board room. Cost not to exceed £700. Drawings to be sent to Mr. Wm. Lister, Thorne, Yorkshire, by the 30th inst. Premium £20.

Architects of Great Britain, Ireland, and France are invited to furnish designs for New Houses of Parliament to be erected in Sydney, New South Wales. £600 will be awarded for the approved design, and £300 for the second best. The style of architecture is left to the competitor. Drawings and estimates to be sent under sealed covers, addressed to the Secretary of Public Works, Sydney, to the care of Messrs. William L. Merry and Co., 36, Cannon-street, E. C. (the commercial agents of the New South Wales Government), for transmission to the colony by steamer. General conditions, together with a contour plan, may be obtained on application to Mr. Weale, 59, High Holborn; Messrs. A. and C. Black, Edinburgh; Mr. H. Campbell, Argyle-street, Glasgow; Messrs. Hodges and Smith, Dublin; Messrs. Philip and Son, Liverpool; Messrs. Thompson, Manchester; or M. Amyot, No. 8, Rue de Paix, Paris. At each establishment photographic views of the locality may be seen. Mr. Weale will give such explanations as may be desired of him by personal application or by post. Designs to be sent in by the 1st of January next.

Designs are invited from Belgian and foreign artists for the erection of an extensive Bathing Establishment, and the construction of a monument, to be placed near the wells of the Pouhon Spa, Belgium. The estimated cost is 800,000f. The designs to be sent to the Communal Secretary of Spa before the 15th August next. 12,000f. will be divided among the authors of the best designs. The plans will be exhibited in Spa till the end of the season. The programme, topographical maps, price of materials, &c., may be procured for 2f. of the following booksellers:—Wollessi, Spa; Desoer, Liege; Office de Publicité, Brussels; Libraire Renouard, Rue de Tournon, Paris. These documents may also be found at the Belgian Consulates in London, Birmingham, Manchester, &c., and all over the continent.

Competitions Awarded.

The designs of Mr. W. Walker have been accepted in competition for the new church of St. Thomas, Radcliffe, near Manchester.

The designs of Mr. Pearce, Clapham, obtained the first premium, and Mr. Budd's, of Westminster, the second, in the St. James's Vestry Hall competition.

The designs of Messrs. Sutton and André, of Nottingham and London, have been selected for the new church to be erected at Hull.

The design of Mr. Walter Damant, late of Plymouth, has been selected for the Exeter Branch Bank.

The designs of Messrs. Peddie and Kinnear, architects, Edinburgh, have been adopted for the new Corn Exchange, Leith.

The Hertford Cottage Building Company have selected a design by Mr. F. Dyball, of London, for cottages about to be built for the company.

The plans of Mr. G. T. Robinson, of Leamington, have been accepted for the additions about to be made to the Worcester Diocesan Training College, Sutley, near Birmingham.

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ARCHITECTURE AT THE ROYAL ACADEMY.

(*Concluded from page* 158.)

"St. Augustine's Church, Dublin" (657), is another design of more than ordinary merit. We gather from a little sketch-plan that the tower (which is in the centre of the west front) is raised upon one bay of the nave; the end walls of the aisles being flush with it, and having their last bays roofed transversely, so as for the ridges to abut into the tower, as may be seen in some continental examples, of which character indeed the whole composition of this front savours. The "Buildings for the 2nd Regiment of the Cheshire Militia, erected at Macclesfield," by Mr. Pownall, probably deserved a larger drawing: as it is, not much can be gathered from the small bird's-eye view (658). Mr. Somers Clark, in his "Premises for the London Publishing Company, Smithfield" (659), shows a large red brick pile, of eight stories high, not over elegant in its proportions. The "Grosvenor Hotel" (660), now erecting at Pimlico, is a much more imposing structure, very creditable to its author, Mr. Knowles. The roofs, in particular, are well managed. "Finchley-hall School" (661), by Mr. E. Roberts, of red brick, has the unusual feature of a circular staircase at one angle, but nothing remarkable besides.

Of the designs for the Manchester Assize Courts, four competitors send views:—Mr. Blackett, in (641), where all the talent is concentrated on the principal tower;—Mr. G. Morgan, in (663), which is hung too high to be scrutinised, but which does not look to have the air of appropriateness at all;—Messrs. Kendall and Mew's (673), showing a Gothic and a Classic superstructure, so totally dissimilar in appearance, that it is at first sight difficult to imagine that they both spring from one plan—that is, of course, *essentially*. Both designs are exceedingly clever and original, the Classic one especially, which is more severe and purely Greek than modern practice usually admits;—and Messrs. Green and De Ville's (684), coarse and uninviting. (664) Messrs. Prichard and Seddon's proposed church at Cardiff shows all the advantage of good proportions over mere detail, and is a favourable specimen of what can be done by little more than well-studied forms judiciously disposed. We may contrast with this the next in number (665), a church which Mr. W. Smith is building in Norwich, which is a most uncouth mass, with scarcely a redeeming point. Mr. Penrose supplies (671) "A design for the completion of the interior of St. Paul's," following out Wren's known wishes on the subject, which he was never permitted to realise. The judgment of the Surveyor was (as he intimates in his 'Parentalia'), instead of painting in the manner now performed, to have beautified the cupola internally "with the more durable ornament of mosaic work, as is nobly executed in the cupola of St. Peter's, in Rome." But as this art was a great novelty in England, and not generally apprehended, it did not receive the encouragement it deserved. The polychrome which Mr. Penrose has introduced is of the slightest kind; indeed, we deem it would be in such circumstances ineffective, for want of strongly marked definite features.

Mr. D. Brandon has views of several mansions either erected or in progress from his designs: we may instance especially (671), Hemsted House, Kent, a well-proportioned Tudor edifice, built apparently of red brick with white dressings; and (677) Taverham Hall, which bears the same impress of the architect as the last. Exceedingly clever, howbeit, a little overdone, are Mr. Gordon Hill's pen-and-ink sketches of Wiston Church, Sussex (672), which he is about to restore. The original edifice was small, and chiefly interesting from a choice sepulchral brass which it contains: the enlargement and improvements now suggested are ably devised, and will add to the picturesqueness of the building.

Two very effective interiors by Mr. Scandreth (679, 680), both from Rouen, merit particular notice, and Mr. Dobbin's "Mosque at Cordova" (678) is also praiseworthy, but over-laboured. In (789) this artist gives a general view of the city itself, and in (816) another Spanish scene—"The city of Valencia." Lord Skelmersdale's mansion at Latham, Lancashire, is undergoing considerable alterations, which are shown by the architect, Mr. T. H. Wyatt, in (681): the style is Palladian. Mr. Ernest George sends a large perspective (682) of his "Design for a metropolitan hotel,"—the gold medal award of the Academy last year, and which we have described on a former occasion. Among the tasteful arrangements in contemplation in appropriating the grounds at South Kensington belonging to the Commissioners of 1851, may be mentioned those for the Horticultural Society, including the elegant arcades, &c. to inclose the gardens; also a Royal Pavilion, proposed to be erected for her Majesty's use. These are both entrusted to Mr. Sydney Smirke, who exhibits a careful drawing of them in (687). One of the most delicate and highly-finished pictures in the room is (689), Mr. Page's "Design for the Bridge over the Golden Horn, Constantinople," which is on the suspension principle, divided into two by a central arched pier or tower, of sufficient altitude to admit of Turkish men-of-war passing underneath; the traffic of the roadway through this pier being by means of a drawbridge. The scheme is altogether a happy one, to which the drawing before us does full justice.

The place of honour is assigned to Mr. E. M. Barry's "View of the new Floral Hall, and Royal Italian Opera-house, Covent-garden" (690), which are now so well known as to render further allusion unnecessary; while over it (691) is by far the most elaborate work in the room,—the "Interior of Messrs. Osler's Gallery, Oxford-street," designed by Mr. Owen Jones. In this design the author's facility of invention in the use of several novel materials is deserving of examination, as suggestive of hints for the future; also the mode of lighting, and the disposition of the polychromy, in all which departments Mr. Jones is an acknowledged master. But the elaboration of the drawing consists no less in the specialities so profusely displayed on the various counters and walls, and which testify to the enterprise, skill, and elegant taste of the manufacturers. Under the circumstances, the minute fidelity with which these are rendered is quite allowable; otherwise it might be questionable why so much labour should have been incurred on so subordinate a matter. Mr. Peck has in (692, 696), exterior and interior views of the new church he is erecting at Maidstone,—a plain, good design. We observe that the nave arches are needlessly severe in appearance, owing to their perfectly plain square soffit; also, that the security of the roof will depend very much on its careful framing, since in point of construction, the collar being so high, and there being no tie-beam, it is open to objection.

"Art in devotion" is the title which Mr. F. P. Cockerell gives to his sole contribution (694), in which we trace an ancient artificer prosecuting the various branches of his work. Of the beauty of this drawing there cannot be two opinions, and the artist has evidently been at considerable pains to express truthfully the means and appliances formerly in vogue for practical working: many of these, as might be expected, were indeed clumsy and uncertain, while the ingenuity and perfection of others have not been excelled up to the present day. In (697) Messrs. Hadfield and Goldie present a "South-east view of St. Peter's Church, Phisboro', Dublin," which is an imposing group, and has a gabled tower in the centre. "Stratton Audley Park" (699), now in course of erection near Bicester, from the designs of Mr. Roger Smith, has been recently illustrated in our Journal. The view before us is however taken from precisely the opposite point, showing the garden front,—on the whole a highly creditable composition, and well planned.

A curious grouping of "Contrasts and Comparisons" has been worked out by W. J. Green (698), but exhibited by Mr. Tite. It is in illustration of the horizontal and vertical principles of architectural composition, the subjects being chosen chiefly from Classic and Mediæval models, to which a few recent ones are added, the whole being indiscriminately mixed. We have not so much fault to find with the buildings themselves as chosen; but for their faulty perspective in very many cases, which almost amounts to caricaturing, there can be no excuse. What, for instance, can be worse than the rendering of the exquisite steeple of Bow Church?—it is out of all drawing and proportion. Mr. Porter's "Design for a proposed international hotel, in the Strand" (700), is a work that should not be overlooked: it is an extensive pile of building, so much so as to appear somewhat high and cumbrous in effect. In (703) Mr. Talbot Bury exhibits a truly architectural and powerfully-coloured picture, such as we are wont to see from his hand, and one, if we mistake not, of which we have seen the companion pictures before. The subject is, the "Grand staircase, New Lodge, Windsor Forest," a costly mansion in the Jacobœan style, which Mr. Bury is now erecting for the Belgian Minister. Mr. J. Drayton Wyatt has a view of the wooden porch, with its singular bargeboard, at Great Burstead, Essex (706); and Mr. W. Ward (705) a faithful representation of the quaint old market-house at Rochford, in the same county.

"A new mansion erecting at Horsemonden, Kent" (708), by Mr. T. H. Wyatt, is apparently of unusual size, but in no other way remarkable, unless it be for the freedom of its details, which seem to be borrowed indiscriminately from Classic and Gothic

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sources. Mr. T. H. Wyatt has been more successful in his other mansion, "Carlett Park, Cheshire" (710), a very fair specimen of modern Elizabethan.

In the "Military Chapel, Warley depôt, Brentwood," of which an interior view is given (709) by its architect, Mr. Digby Wyatt, the basilica type has been adopted, and Romanesque character imparted to the details. The peculiarity of the building is, however, its being of red brick throughout, both externally and internally, except such portions of the dressings and carving which are necessarily of stone. The plan indicates some new arrangements, which nevertheless contribute to the massing and good effect of the whole.

The selected design for the Town-hall, Bishop's Auckland (717), by Mr. J. P. Jones, has the merit of being thoroughly characteristic, though, it may be, a little *outré*. An open arcade on the ground floor is a useful as well as effective feature. The noble triple portal of Abbeville Cathedral is well shadowed forth by Mr. Jenkins (719); as are also many other fragments of continental buildings, which catch the eye here and there on the wall. As the majority of these partake however more of an artistically picturesque than architectural character, we shall not stop to examine them here; but we should be loth to include in our category the unapproachable works of David Roberts, who exhibits no less than five: one (49) being from Venice, one (158) from Antwerp, another (212) the interior of the cathedral at Pisa, and (286, 302), two views in Rome—the Coliseum, and the Forum; the former of these two subjects has also been chosen by another artist, Mr. Bridell (383).

The interesting ruins of Rivaulx Abbey have tempted the pencil of Mr. F. Turner, who in (243) shows the Refectory, a wondrous specimen of Mediæval architecture. Mr. G. Stanfield has (250) a telling view of St. Michael's Church, Ghent; and Mr. W. Callow (343) an equally enchanting sketch of the Piazza at Padua. Mr. E. W. Cooke as usual revels in Venice, and gives us (422) the Piazzetta of St. Mark. Besides the few several pictures now enumerated, there are various others of this class of more than average interest, since their artists have associated them with some leading historical interest, which will not need more specific allusion on our part. We are gratified to observe in these, as well as in the pictures generally, a tone of marked improvement, from which we venture to augur still greater successes in future.

THE NEW ROYAL DRAMATIC COLLEGE, WOKING.

A most praiseworthy addition to the benevolent institutions for which our country is so distinguished was made of late, when the Royal Dramatic College was founded; which having speedily secured for itself public sympathy and a "name," has now obtained also a "local habitation" at Maybury, near Woking, where the first stone of the important building we are about to describe was laid by his Royal Highness the Prince Consort on the 1st of last month, in the presence of a numerous and highly influential assemblage. The site, which is in close proximity to the South-Western Railway, was given for the purpose by the London Necropolis Company,—no trifling offering, when the extent of ground required, and thus liberally accorded, is borne in mind: the frontage alone of the new buildings stretches for about 900 feet, besides which there are ample allotments for garden-terraces, playgrounds, &c.

The main outline of the block plan is strictly uniform, there being a central mass of building, with ten houses on each side, ranged slightly in arrear, yet communicating both with it and with one another by an open arcade or cloister, which is continued all along the front, thus affording a complete and ready access throughout, in any kind of weather. At the extreme ends of the dwellings the outline is again broken by two projecting wings, respectively devoted to boys' and girls' schools, and having master's and mistress's residences attached to each.

The accommodation is for forty inmates, who will be located in the twenty houses already referred to. These houses being two stories in height, and arranged on the "flat" principle, will each contain two residences, the apartments of every inmate being totally distinct from those of his neighbour. Each will have a living-room 11 feet by 12 feet, a sculiery 8 feet by 6 ft. 1 in., and a bed-room 11 feet by 10 feet.

The centre building is appropriated to special purposes, the principal being a hall, carried up externally as a tower, and forming a leading feature in the design; a large picture-gallery, in connection with which is the sculpture-gallery and library; and also a committee room. In the upper stage of the tower is a niche containing a statue of her Majesty the Queen; and a pyramidal turret at one angle agreeably diversifies the sky-outline of the whole.

The wings, serving as school buildings, are partially detached, excellently planned, and highly picturesque in design, owing to the play of light and shade on their several receding surfaces. In these groups, too, an octagonal staircase connected with the entrance, and a clock, gabled out of the side wall at the level of the eaves of the roof, are well-adapted as well as useful features.

The walling surfaces are chiefly red brick, relieved occasionally by grey brick bands; the quoins, dressings, and ornamental features being of Bath stone. By a happy idea, however, the architect has cleverly prevented the monotonous appearance which so large a surface treated in the same materials throughout might have presented, by using, in the walls of the three most prominent portions of the front—viz. the centre building and the two schools—Kentish ragstone, instead of brick. As to the good judgment which has suggested this deviation there can be no question, while it is quite in keeping with the architectural principles of the Domestic-Elizabethan style, in which the design is being appropriately carried out. As a means of still further isolating these features, their roofs will be covered with pattern Broseley tiles, while those of the range of buildings behind will be of green and purple slate.

The design was selected in public competition, the architect being Mr. W. Webbe, of 10, Buckingham-street, Adelphi; and the contractor for the execution of the works is Mr. Perry, of Cambridge-heath, Hackney. The whole of the ground will be raised considerably above the present surface, and at the entrance will be placed a handsome lodge.

The rapid success which has attended the establishment of the Royal Dramatic College may be traced in a great measure to the self-denying exertions and ability of its elected Master, Benjamin Webster, Esq., and those of its Honorary Secretary, J. W. Anson, Esq. It should be added, too, that several other distinguished members of the profession have undertaken to defray the cost of one house each; while other well-wishers have not been tardy in helping forward, in various ways, so good a cause.

ON BUILDING WOODS: THE CAUSES OF THEIR DECAY, AND THE MEANS OF PREVENTING IT.*

By G. R. Burnell, F.G.S., F.S.A.

The use of timber for building purposes being of an importance even greater than that of the use of stone, has naturally attracted more attention from the practical and scientific students of the arts of construction than has been devoted to the study of the cognate subject above mentioned; but the information recorded upon the conditions under which timber should be employed is dispersed through so numerous a body of authors, that it appears to have become almost necessary to condense it into some popular form. The introduction of several hitherto unknown descriptions of timber into our markets, the recent startling tale of the decay of our gunboats, and the application of certain processes for the purpose of preventing the decay of timber, appear to render opportune a short review of the state of our knowledge of the subject, and also a discussion of the value of the respective new materials and new processes desirable.

Description of the Timbers generally used for Building purposes in England, whether of Native or of Foreign Growth.

1. *Native-grown Timber.*—The woods employed for building purposes in our large towns are so exclusively derived from foreign countries, that professional architects especially are apt to overlook the importance of the resources of this description furnished by our own land; yet it may fairly be stated that the supply of the wants of agricultural builders, and of many of the trades connected with that important branch of natural production, is derived exclusively from the English forest trees. Such woods as the lime, the maple, acacia, wild cherry, thorn, and willow, are frequently used for carpenters, joiners, turners, furniture makers, and wheelwrights' purposes in agricultural districts; the holly, pear, walnut, sycamore, and yew, are more eagerly sought for by what are called the Tunbridge-ware makers; the poplar is used for box making; the birch, for rough carpentry and

* Abridged from a Paper read before the Society of Arts.

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scaffolding purposes; the elm is used for farm buildings, for carpentry intended to be constantly submerged, cart building, and for coffin-making; the alder is sought for on account of the extraordinary value of its charcoal for gunpowder manufacture; the horse chesnut and the sweet chesnut are used for farm buildings occasionally; the hornbeam and ash are used for the most important details of millwrights' work on account of their hardness, evenness of grain, and tenacity, and the ash in large lumps, or wide planks, is used for chopping boards or blocks, counter tops, ironing boards, or other analogous purposes; the Scotch fir, silver fir, larch, spruce, and other varieties of the pine tribe, are extensively used for rustic carpentry, and even for railway sleepers or timber platforms kept constantly under ground; the beech is used, as a hard wood, in rustic carpentry, and for pile-driving when the wood is permanently submerged; whilst the purposes to which the English oak are applied are too numerous and too well known to require detailed notice. In town buildings, the English woods most commonly used under the directions of architects and engineers are, however, only the elm, ash, oak, beech, and occasionally the sweet chesnut, and it is to them alone that attention will here be called.

The elms grown in England belong to several species, of which the small-leaved elm (*Ulmus compestris*), the cork-barked elm (*U. suberosa*), and the wych elm (*U. montana*), are the most commonly diffused, and the first of which may be taken to represent the type of the group. It thrives in almost every variety of soil in the south and west of England, and grows into trees of from 75 to 100 feet in height and 4 feet diameter. The wood of the full-grown healthy trees is of a deep brown colour, compact, free from knots, and of a fine grain, unfit, however, to take a polish of any description; it loses, according to Loudon, as much as 66 per cent. of its weight in drying. Elm timber has great transverse strength, but even in this respect it is far inferior to the oak; and it is on account of its peculiar powers of resistance to strains that it is hardly ever used to support heavy loads, whilst it is well adapted for such situations as would expose it to concussions. After being seasoned this wood does not split or crack, and it is durable when constantly exposed to the sun or to water, but it rapidly decays in situations where it is alternately exposed to be wet or dry. The piles of old London-bridge were made of elm, and the wood after 800 years was as sound as on the first day of its use. The water-pipes used until the commencement of this century were bored out of elm trees; and at the present day, ships' pumps, boxes of wheels, blocks, dead-eyes, and other wooden furniture of rigging, are constantly made of this wood. The colour of the wood is in old elm trees of an oak brown, in younger ones it is brownish white, with a shade of green; and coachmakers and others who use this material observe that the old trees yield a wood of a far more brittle nature than the young ones do. The seasoned elm weighs about 36·7 lb., its specific gravity is 0·588, and there are usually about 61 feet to the ton; its cohesive strength is considered to be 13,489 lb.; its resistance to a crushing weight 10,331 lb. per inch superficial. It may be essential even here to notice a singular illustration of the lack of practical information on the subject of building woods amongst our official authorities, viz. that Lord C. Paget in the House of Commons said, that in consequence of the scarcity of seasoned oak the contractors for the celebrated gunboats had been allowed to use elm planks instead of oak. Now as the gun-boats were nearly all drawn up on the slips after a few months' use, the elm planking in question was placed in precisely the conditions which would have led to its decay had it been desired to produce that result.

The description of ash used in this country is the *Fraxinus excelsior*, or common ash, which frequently grows into trees of from 90 to 100 feet in height and about 6 feet in diameter. Ash soon rots in damp, or in alternately wet and dry situations; and if felled when full of sap it is singularly exposed to the attacks of worms or the boring larvæ. It is very flexible, but tough and elastic, and on these accounts, whilst it is practically excluded from use in ordinary building operations, it is much sought for by agricultural implement makers, wheelwrights, and engineers. The weight of a foot cube of this wood is about 49 lb., its specific gravity 0·767, and there are usually 45·7 cubic feet to the ton; the tenacity per inch superficial is about 17,207 lb., and the resistance to a crushing weight 9203 lb. per inch superficial. The best ash is grown on free loams with a mixture of gravel; the trees grown in cold wet soils being sorely exposed to what woodsmen call "the canker," which displays itself in black spongy masses on the stem and branches. The bark and the sap wood of the ash are exposed to the attacks of many destructive insects, of which the *Hylesinus fraxini* is the most mischievous.

The oaks most commonly grown in England belong to the respective varieties of the *Quercus pedunculata* or the *Quercus sessiliflora*, and it may at once be observed that the differences between the qualities of the woods furnished by those varieties are so slight that, unless when specially mentioned as appertaining to one of them, the following notice of the properties of the oak may be considered to apply to both the above-named varieties. For all building purposes wherein strength is required,—whether to resist crushing loads, transverse strains, or efforts of torsion, or wherein hardness and durability are sought for,—oak is beyond all comparison the most valuable and the most beautiful wood. If the alburnum be removed, the heart-wood will be found to resist almost every condition of moisture, or of alternations of wetness or dryness, provided always that the moist atmosphere be not allowed to stagnate around the wood. In joiner's work the variety of colour in the grain, or as workmen call it "the flower" of the picked oak planks, known by the technical name of "wainscoat," causes it to be highly prized, and the beauty and durability of the woodwork in the roofs, stalls, pulpits, rood screens, &c., of our mediæval churches and halls, may well explain the marked preference of our builders for this invaluable material. It seems that the *Q. pedunculata* yields a timber which is for some purposes superior to that of the *Q. sessiliflora*, for the latter does not split so freely, and is, therefore, less fitted for lath or pale rending; and, moreover, although heavier than that of the *Q. pedunculata*, the wood of the *Q. sessiliflora* is said to be more exposed to warp and crack in seasoning. For shipbuilding purposes, for carpentry exposed to water or in damp positions in the air, there are no substantial differences of resistance; and timber of both these kinds may be used as they may come to hand.

The oak trees converted for building purposes are not usually of more than 100 or 130 years old, although for naval architecture, wherein large scantlings are required, trees of much greater antiquity are used. It was formerly by no means rare to meet with oaks ranging from 75 to 130 feet in height, and 10 feet in diameter in the middle of their height; but the excessive demand for this class of timber tends to make such monsters of the forest more and more rare: and at the present day it is only on extraordinary occasions that the long straight sticks of English oak are to be met with of more than two feet scantling. The colour of oak wood is of reddish tinge, and the larger septa and medullary rays are numerous and distinctly marked, giving rise to the flower; the grain is tolerably straight and fine, and generally free from knots, the wood itself being of sufficient evenness of character and density to allow of its being polished either by oil or by lac varnishes. It is said that the *Q. sessiliflora* wood has less flower than its cogener; and that in its grain it so much resembles the sweet chesnut as to have given rise to the often-repeated tales about the use of the latter in our mediæval buildings. The weight of a cubic foot of seasoned oak is said to be 58·3 lb.; its specific gravity is 0·934; there are usually about 38·3 cubic feet to the ton; the tenacity per square inch is 17,300 lb.; and I have applied a weight of 11,240 lb. per superficial inch on a cube of English oak without producing any permanent change in its elastic powers. All oak presents the inconvenience of splitting and warping in the seasoning; and it is on this account especially that it is so important to use none but seasoned timber in ship-building, and the best oak is liable to objection on the score of the gallic acid it contains, which has a marked action upon any iron nails, bolts, or fastenings used in connection with it.* Young oak is tough, often cross-grained and hard to work; old oak is brittle, but also more easily worked. Oak trees, it may be added, are exposed to the attacks of numerous insects, some of which, such as the *Cossus ligniperda*, bore holes of more than half an inch diameter into the very heart-wood, and continue their ravages at times even after the tree has been converted to building purposes. The *lymexylon* is also a destructive enemy of the oak, but he seems to confine his attacks to the alburnum. Oak trees grow the best upon deep and rather stiff clays, provided the upper surface be

* It appears from the account of the experiments recorded in the *Times* of May 28th, that the action of this gallic acid upon the coating of the iron-plated ships is of a very energetic nature, and it seems therefore to me that if vessels of that peculiar description should be adopted, it would be preferable to use, in their external portions at least, nothing but creosoted fir, which has no destructive action on iron.

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kept free and open by means of surface or subsoil drains. The quality of the wood seems to be injuriously affected when there is an abnormal quantity of the peroxide of iron present in the deep soil.

The beech trees which furnish the best timber for building purposes are obtained from the chalk districts capped with loam around London, and they there attain the dimensions of the largest forest trees of the second class, or present boles from 30 to 40 feet in height, and from 3 to 4 feet in diameter. This wood is hard and brittle, varying in colour from a pale brown to white, according to the nature of the soil, the darker colour being usually considered to be indicative of the superior description; the transverse fibres and the horny rings are distinctly marked, producing an agreeable variety of colour, and it may be worth while to remark that the difference of colour between the heart-wood and the alburnum is less distinctly defined in beech wood than is the case in either the ash, elm, or oak. Beech is much used for piles and for water-works generally, provided it be kept constantly submerged; but if exposed to alternations of wet and dry it decays with fearful rapidity. At all times this wood is exposed to the attacks of beetles, and it cannot be used even for household furniture without being impregnated with some kind of varnish as a defence against those insects—a very curious fact, be it observed in passing, for the growing trees are remarkably free from the attacks of wood-devouring insects. Beech is easily worked, of a close, fine texture, but is not susceptible of receiving a polish. The weight of a cubic foot is 43·12 lb.; its specific gravity is 0·777, and there are 51 cubic feet to the ton: the tenacity per superficial inch is considered to be 16,817 lb., and the resistance to a crushing force to be 9048 lb. per superficial inch.

At the present day chesnut wood is not very largely used. Indeed, there is so little of this material brought into the market, that the principal motive I had in view in alluding to it was for the purpose of referring to the tales so commonly told about the use of the chesnut in Westminster Hall, and elsewhere. Careful examination has shown that the roofs so referred to were really executed of wood of the *Quercus sessiliflora*, which is very like that of the sweet chesnut, and must always have been more common in North-western Europe than the latter could possibly have been. The small quantity of chesnut now used near London is employed for gate-posts, barrel staves, &c., and it is remarkable for the very small relative proportion of the sap to the heart-wood. For general purposes the chesnut is of far less value than either the hornbeam or the common varieties of native-grown firs, which the limits of this paper will prevent us from noticing as they merit.

2. *Imported Timber.*—The principal supplies of timber used in our large towns are, at the present day, derived from foreign countries, as was before stated, on account of the facilities which the inland navigation of our country furnishes for their delivery, and of the continually diminishing quantity of English grown wood. We therefore find that the softer woods of the fir tribe are obtained either from America or Northern Europe, the hard woods from every quarter of the globe, whilst the furniture woods are obtained of every variety and from every imaginable source. This rough classification of the particular kinds of wood will be adopted in the subsequent notice.

The fir-woods now most generally used in England, that is to say since the equalisation of the import duties on timber, are obtained from the countries situated upon the shores of the Baltic; the large or baulk timber of 14 inches square or upwards being obtained from Riga, Dantzic, Memel, or the Prussian dominions, and the German provinces of Russia; the scantlings of about 10 or 12 inches square are obtained from Sweden, and the scantlings of about 8 inches square from Norway. The manufactured goods, as the various kinds of deals and planks are called, are obtained from either or all of the above-named sources; and they are known under the name of planks when more than 11 inches wide, deals when about 9 inches wide, and battens when 6½ or 7 inches wide; deals and planks are usually 3 inches thick, and battens are 2½ inches thick. All these manufactured goods may be either white or yellow, and the above specific terms may occasionally be applied to the spruce goods as well as to the true fir-woods. As to the quality of these kinds of timber it may be observed that, as a general rule, the firs obtained from countries where the mean temperature is not severe are more regular in their structure, though perhaps softer, than those grown in very cold situations, and that the Memel timber is on that account superior in its strength to the Swedish or Norwegian, and that the Riga deals, or the Norwegian deals grown within the zone affected by the temperature of the Gulf stream, are superior to the Archangel deals or those grown on the more southern coast of Sweden. In the best timber the annual rings are thin, and the horny parts are of a bright red colour, especially when the trees have not been tapped for the purpose of extracting the resin; an operation which is carried on to a great extent, and which materially diminishes the elasticity and the durability of the timber. Many of the accidents before alluded to of a nature to superinduce the decay of the wood in the shape of druxy knots, fungoid growths, &c., are to be met with in the baulk fir; and precautions must therefore be taken in employing it to secure a free circulation of air. Good sound fir is however very durable, and indeed by some engineers it is considered to be more so than even oak itself. At any rate the permeability of fir renders it more susceptible of some of the processes for the preservation of timber to be noticed hereafter, and this, under some circumstances, gives it a species of advantage over the more naturally durable material. On account of its lightness, stiffness, and durability, the fir is commonly used for girders, joists, rafters, and framing in general; for joiner's work it is used externally and internally, on account of its being more easily wrought, standing better under the ordinary variations of temperature and light than oak, and of its being considerably cheaper. The grain is usually straight and regular, but it is very frequently deformed by knot, and it is very rarely of a character to allow of its being used without being painted. The different kinds of fir vary in their physical properties, but it is usually considered that the Riga timber weighs 47·06 lb. to the cubic foot, and has a specific gravity of 0·753; the Christiana deals weigh 43·62 lb. to the foot cube; the Memel deals, 36·87; and Norway spruce, 21·25 lb. The tenacity of the Riga timber is considered to be about 12,857 lb. per superficial inch, and the resistance to a crushing weight 6856 lb.

The fir timbers imported at the present day from the Atlantic ports of America are almost exclusively of the pine tribe, such as the yellow pine and the pitch pine. The former of these woods is much used for joiner's work, on account of the singular beauty, closeness, and regularity of the grain, which renders it of great value for the working of mouldings; it is however a very soft and by no means a durable wood, and it is not therefore much used for external works. The pitch pine, on the contrary, is a remarkably close-grained, hard and resinous wood, free from knots or shakes, and possessed of great durability, for which reason it is employed for the treads and risers of wooden staircases, the decks of ships, and floors in first-class houses. The weight of the yellow pine is 28·21 lb. per cubic foot; that of the pitch pine, 41·25 lb.

There is a description of fir lately introduced from the Pacific shores of America, from our own colony of Victoria, which seems to me to possess such remarkable qualities, that although the numerous philosophical questions it gives rise to have not been examined as yet in any elaborate manner, I cannot refrain from dwelling upon this Vancouver's Island timber with particular detail. The wood comes to this country in logs and in manufactured goods. Instead however of being only 14 to 16 inches square, and 60 feet long at the maximum, as in the case of the Baltic timber, I have seen one stick of the Vancouver's Island timber not less than 127 feet long, and about 42 inches square at one third of the height measuring from the butt-end, which butt was about 50 inches square; this log actually contained 1307 cubic feet of timber, and it can hardly be considered an exceptional illustration of the capabilities of this peculiar description of timber, for there are at present in our docks or in private ship-building yards many logs of nearly equal dimensions. Now this timber, from some rough experiments I have myself made, is not only larger and longer than either the Baltic or the American firs or pines, but its tenacity is greater, and its resistance to a crushing weight apparently superior; indeed, when loaded as a girder with the weight in the centre to the point of instantaneous rupture, the Vancouver's Island wood bore weights which were to those borne by English oak as 13 to 12, and to those borne by the Baltic fir as 13 to 8; and I subjected cubes of the three woods, measuring 3 inches on the sides, to weights of 45 tons each, or 5 tons (11,240 lb.) on the inch superficial, when I found that the permanent elasticity of the oak was not affected, that of the Vancouver's Island timber only slightly

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so, whilst the Baltic timber was permanently and perceptibly compressed. I do not hesitate therefore to say that for girders, masts, large timber framed-work, &c., the Vancouver's Island timber is superior to ordinary fir, on the score of its strength; and as it only weighs about 42 lb. per foot cube, it is equally preferable to oak on the score of its lightness. For joiner's work, the straightness, freedom from knots, deep warm colour, and beauty of the flower, certainly place the Vancouver's Island timber in a superior position to any other of the fir or pine woods; whilst its greater hardness would in certain positions, as in staircases, floors, &c., compensate for any slight increase in the price of labour occasioned by that hardness. I have used this Vancouver's Island timber in the joiner's work of the board-room of the Equity and Law Life Assurance Society, a very elaborate specimen of Elizabethan panelling, and I think that the result of the experiment has been eminently successful. On some subsequent occasion it may be necessary to refer to some observations made upon the destructive distillation of this wood; but at present it may be as well to observe that it seems to affect iron nails and bolts driven into it in somewhat the same manner as oak does.

Large quantities of oak are imported into this country from Northern and Southern Germany, Italy, and America. The oak shipped from the northern German ports arrives in the shape of logs, and is cut into what is called Dutch wainscoat, by the same strange confusion of words which makes us so constantly translate Deutsche by Dutch. The Dutch wainscoat is not obtained in large sticks, and on that account it is only fitted for joiner's work; but for the latter purposes it is much esteemed on account of the beauty of its flower, its colour, and durability. The oak obtained from South Germany and from Italy is procured in logs of very large dimensions; it is remarkably sound, strong, and free from diseased knots, and is therefore much used for marine engineering works. Dantzic oak weighs 47·24 lb. per cubic foot. It would be possible to increase the area of supply of this south European oak, for there are immense forests of this wood in Spain, the Mediterranean Islands (especially Corsica and Sardinia), and it would be easy at the same time to obtain from those sources large supplies of the evergreen oak, which for some purposes would even be preferable to ordinary oak, though its extraordinary specific gravity (it is heavier than water) would of course oppose its general use. The American oak is less hard, less beautiful in its grain than the European oaks, and it is less liable to decay if exposed to alternations of dryness and humidity. There is a wood known in trade by the name of African oak, though the correctness of the term may be questioned, of great hardness and durability, which has lately been applied for the planking of turning bridges, the entrances of offices exposed to great traffic, &c. It seems to have answered remarkably well in such positions, but it does not arrive here in the scantlings necessary for framed engineering or carpenters' work, and must therefore remain of comparatively little use. All these oaks are subject to the attacks of insects, either in the forest or afterwards when used in buildings.

Teak is a wood which has of late years been much used for ship-building, house, and even carriage joinery. The best varieties are obtained from Burmah, or the ports of Rangoon or Moulmein, and it is by no means rare to meet with sticks of perfectly straight teak, 60 or 70 feet long, and about 2 ft. by 2 ft. 6 in. scantling. The wood is very hard, tough, and, when sound, of great strength and tenacity; but unfortunately the trees in their native forests seem to be exposed to the attacks of numerous insects, and to accidents of a nature to produce serious local diseases in the timber, so that hidden defects of extremely dangerous character are often to be met with in the soundest-looking sticks. The weight of a cubic foot of dry Moulmein teak is 41·06 lb.; its tenacity per superficial inch is 15,000 lb.; and its crushing force per superficial inch 12,101 lb.; the wood is easily worked and takes a good polish; though porous, it is very durable in exposed situations, and it is said to contain some oily properties, which render it less injurious to iron than oak.

The peon, another Indian wood, formerly exported to some extent, has latterly been regarded with such disfavour that it is now hardly ever imported. It may also suffice for our present purposes to say, of the kowrie, a New Zealand wood, of the Australian iron-bark, of the Australian red cedar, of the sabacue, and some other descriptions of East Indian woods, of which samples are to be found in our docks, that although they may respectively present advantages of some description or other, they are not yet sufficiently known to warrant the formation of any definite opinion as to their comparative merits.

The greenheart timber, imported from our own colony of Demarara, is worthy of particular notice, on account of the reputation it possesses of enjoying immunity from the attacks of marine boring worms; and for this reason it is now being largely used at Liverpool and elsewhere, in operations connected with hydraulic engineering. I beg, however, to impress upon engineers the necessity for caution in the use of this timber, because from the state of some logs of it which I saw lately in the West India docks (especially of two logs bearing the dock numbers 162 and 172, ex-Perthshire), I am convinced that the greenheart enjoys no immunity whatever from the attacks of land insects. Without pretending to prejudge the question of the immunity of this wood from the attacks of marine insects, it really seems to me important to examine the conditions under which the reputation of the greenheart has been obtained.* It will be necessary to revert hereafter to this subject; and after stating that the greenheart often arrives in our ports in scantlings of 16 inches square and 70 feet in length, that it certainly is hard, strong, and durable, in alternately wet and dry positions, I would pass from the consideration of these rarer descriptions of building woods by saying that the hacmatack, formerly used for railway sleepers to a great extent, is now almost forgotten; that the American rock and swamp elms are sometimes used for pile driving and other engineering works (I believe for no valid reason), in preference to the cheaper and more commonly known European woods; that the American birch is also but little superior to the European birch; that the lancewood is only used for carriage building, or substances requiring a light and peculiarly tough material of small scantling; and that the Florida or the pencil cedar is never used in England for anything but joiner's, or rather cabinet-maker's work. This latter remark may be extended to the rose-wood, ebony, bird's-eye maple, Hungarian walnut, satin-wood, gutta-percha-wood, zebra-wood, and some fancy woods obtained from the tropical regions of the East or of the West Indies,—so that a notice of them may be dispensed with on the present occasion.

There is one description of furniture wood however which has lately been so much used in shipbuilding, and which seems to possess such valuable properties for ordinary building purposes, that it may be expedient to notice it somewhat more in detail. I allude of course to mahogany, a wood obtained from some of the islands of the Carribean sea, or from the mainland of Central America. Our market supply, in fact, is derived either from the island of St. Domingo or Hayti, from the southern extremity of Cuba, or from Honduras; and the qualities of the various kinds follow the order in which they have been named. The best, or the Spanish mahogany, comes from the sea-board on the south of Hayti, and is a singularly hard, strong, and beautiful wood, of a rich brown colour, variegated by a flower of an equally remarkable character. It is far too valuable for building purposes, and is sometimes sold for as much as £6 per cubic foot, when good fir of nearly equal value for constructive purposes would only cost 2*s.* at the maximum. The Spanish mahogany is, therefore, only used for cabinet-maker's work of the best description, and generally in the form of veneers. The Cuba mahogany is frequently as good as the second-class Spanish, and, in these days of fraud and adulteration, it is no doubt often made to pass muster under the name of the better kind; but the Honduras wood is so distinctly inferior to the Spanish, that no ordinary judge could possibly be mistaken in the normal samples. Honduras mahogany is lighter, of a straighter and more spongy grain, without much flower, and on these accounts it is little sought for by cabinet-makers. But it occurs in larger sticks, of a form and scantling more adapted for constructive purposes than the Spanish variety; and on these accounts, as well as on account of its peculiar mechanical properties and its cheapness, the Honduras wood has lately been much used for shipbuilding. The Spanish mahogany is hardly ever obtained in logs of more than 10 feet in length, by 20 or 24 inches square, whereas the Honduras trees often yield logs 40 feet long by from 48 to 72 inches in diameter. The weight of the Spanish wood is said to be about 50 lb. per cubic foot; the tenacity per superficial inch is 16,500 lb; the crushing force 8198 lb. All kinds of mahogany are said to be very durable and

* Since the text was written, I have been favoured by the communication from C. Johnson, Esq., of a piece of greenheart timber from Victor Bay, Panama, completely riddled by the *teredo*. This only renders it more necessary to seek an explanation for the asserted immunity of this wood in other situations.

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free from worms when kept constantly dry; they are not exposed to warp or to crack under the influence of the sun's light and heat, but they do not resist alternations of wetness and dryness, and I would therefore venture to suggest that they should not be used in any of the lower framework of ships, or in portions of house constructions, such as sashes, &c., exposed to those conditions of decay. The price of the commoner descriptions of Honduras timber, it may be added, does not exceed that of oak of equal quality. It has been supplied lately in large quantities at the rate of about 5*s.* or 5*s.* 6*d.* per cubic foot. Some small parcels of mahogany are occasionally received from Jamaica or the other West Indian islands; but they are of a quality so much inferior even to the Honduras wood that they are practically unknown to wood-buyers.

The Causes of the Decay of converted Timber, and the generally known processes for its prevention.

In addition to the causes of decay referred to in the previous portions of this notice (arising from the effects of the vital disorganisation of the trees by the wounds superinduced by the disruption of branches, blows, sun strokes, frost, lightning, or from the attacks of the countless insect plagues to which trees are exposed during their period of growth), timber is exposed, after having been felled, to another class of destructive actions arising from the decomposition of its elements, under the ordinary laws of organic chemistry, and occasionally to the attacks of other insects than those above mentioned, when used in certain positions. The marine boring-worms are the most dangerous of these insects, and they will be more especially noticed in the following remarks.

The first description of decay, arising from organic decomposition in wood, is produced by the changes which take place in the sap retained in the wood at the period of felling; for the albuminous portions of that sap commence a putrefactive process directly they meet with the conditions of warmth and heat necessary for its development. All timber must then, whether it be the sap-wood or the heart-wood, be placed in situations which would allow the sap to exude or to evaporate, and this process is the one technically know by the term "seasoning." Evidently the period of the year when the tree is felled must have an important influence on the mode of seasoning; for in the winter the circulation is torpid, and there is then far less sap in the pores than there is when the vital functions of the tree are in full play. Nevertheless timber felled in winter requires a certain amount of seasoning; and, equally with wood more highly charged with sap, it will decay if that fluid should not be allowed to escape. The sad tale of the decay of the gunboats may be referred to as an illustration of the danger of shutting up unseasoned timber; and unquestionably the dockyard authorities who neglected to provide means of establishing a current of air through the frame-work of the vessels, avowedly built of unseasoned timber, should be held partially responsible for their decay. Wood such as Lord C. Paget stated these vessels to have been built of, must of necessity have decayed by what is called wet rot, under the circumstances these boats were placed in. It may be as well to state that the term wet rot is applied to the decomposition which takes place in timber containing sap and exposed to moisture. If the sap-wood or the alburnum be cut from a tree, and the heart-wood be exposed to an energetic dry current of air, there will be no danger of its perishing by this particular process, and it therefore follows that if the sap or sap-wood cannot be effectually removed, it is necessary to prevent the destructive decomposition of the sap by treating it with some fluids which should be able to form at once with it indestructible compounds.

It frequently happens, however, that during the growth of trees the druxy knots before alluded to have established the germs of a putrefactive process in the wood, which cannot be stopped by any process of seasoning; and I myself suspect they can only be arrested by the injection of creosote. There are occasionally no doubt difficulties attached to this mode of preserving timber on account of the impermeability of the wood, and there are practical objections to its application for building purposes. But whenever knots of the description referred to may be suspected to exist in timber, especial precautions should be taken to prevent its being used in situations where it is likely to be covered, or where its decay might compromise the stability of the structure into which it enters; and as the mere lapse of time required for seasoning would allow the decomposition of very bad druxy knots to display itself, there seems to be the more reason for attaching importance to the use of seasoned timber in the frame-work of ships.

But seasoned or unseasoned timber alike are exposed to the cause of decay specifically known by the name of the dry rot, which is considered to arise from the development of several species of fungoid growth in the wood; or, according to Dr. Birkbeck, of the *Boletus, Agaricus, Lycoperdon, Mucor*, &c. It would seem as though some of the organic tissues of the wood—not the sap, observe—decomposed under certain conditions of the surrounding atmosphere (as in close, damp, confined air), and that they thus furnish, as it were, a soil for the growth of the fungi, which in their turn disintegrated the remaining portions of the tissues by their mere mechanical expansion in growing. The wood becomes in fact reduced to a mere powder, and may then be rubbed away by the finger, sometimes with a rapidity quite alarming. There is also this particular danger about the dry rot, viz., that the germs of the fungi producing it are carried easily, and in all directions, in a building wherein it once displays itself, without necessity for actual contact between the affected or the sound wood; whereas the communication of the disease resulting from the putrefactive fermentation, or the wet rot, only takes place by actual contact. It may possibly be the case that woods grown in certain soils are more exposed to dry rot than others are, and that the germs of the fungoids are taken up by the spongioles of the roots; for timber grown in situations where large fungi abound are said to be more exposed to this disease (dry rot) than those which are grown on dry, well-drained soils. At any rate, wood kept for any length of time in situations where it is exposed to become covered with fungi is very likely "to take on" the dry rot at an early period; and I feel it therefore to be my duty to state publicly, that much of the timber arriving from the north of Europe leaves the ships in a state which seems to me to contain the germs of decay; and that the method of stacking the timber and deals in some of our docks is often very dangerous. From whatsoever source the fungoid growth producing dry rot may proceed, if once it should be recognised to exist in a building, the affected parts, and all the wood-work around them, should at once be removed; if the various processes for preserving timber should not then be applicable, great precautions should be observed to cut off the access of moisture, and to ensure a free circulation of air around the newly-fixed wood.

The insects which prey upon growing timbers very rarely attack the qualities of wood used for constructive purposes, because in almost all cases the soft alburnum of the trees used for such purposes is cut away, and the bark and bast are entirely removed, so that the few larvæ which may have been left in the rest of the tree perish for want of nourishment as a general rule. There are however, as was before observed, some insects which prey on what may be termed dead timber, such as the *Lymexylon navalis*, the *Sirex gigas*, the *Callodium bajulum*, and the various tribes of ants. At times their ravages are very serious, especially in the case of oak timber stacked in large quantities, which in the north of Europe is exposed to the attacks of the *Lymexylon*; and of all descriptions of wood in warmer climates which are exposed to the attacks of the destructive termites, or the white ants. In sea-water there are two species of insects which commit great ravages, viz., the *Teredo navalis*, and the *Limnoria terebrans;* and they devour indistinctly the alburnum or the heart-wood with such rapidity that in a very few years large sticks of timber, whole piers in fact, are destroyed by them. It is said that the *teredo* was imported into the seas of northern Europe by the Dutch from their colonial possessions, about the middle of the 17th century; but I suspect that there is little reason for this opinion, and that the *teredo* has been a constant inhabitant of our coasts at least from the time of the deposit of the London clay. About 1660, however, the safety of Holland was seriously compromised by these animals, and since that period the attention of engineers and naturalists has been earnestly and anxiously directed to the study of the best method of combating this apparently insignificant enemy. The habits of the *teredo* have thus been carefully studied; but those of the *limnoria* are not so well known.

Of these causes of decay it is singular that the most general and the most fatal, viz., the wet rot, has attracted less attention than the more startling but less common evils—the dry rot, or the destruction by insects. The methods of prevention and cure for either of the rots are, however, fortunately nearly the same,

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and they may be described by saying that if some of the more recently discovered processes for the preservation of timber cannot, for economical reasons, be resorted to, no unsound timber, nor timber containing sap or sap-wood should be employed in positions where it would be covered in such a manner as to prevent its examination and repair. Great precaution should be taken to insure a perfect circulation of air, and a freedom from moisture, to all unprepared timber, let it be ever so sound, free from sap, druxy knots, star, cup, or ground shakes. If for constructive purposes it be necessary however to use timber in the above dangerous positions, some one or other of the processes for resisting the chemical changes in the tissues of the wood must be resorted to.

These processes are all founded on the principle that it is essential to inject some material which should at once precipitate the coagulable portion of the albumen retained in the tissues of the wood in a permanent insoluble form, which should not hereafter be susceptible of putrefactive decomposition. For this purpose many substances, many solutions, have been employed with variable success, of which the most important and best known are—1. Kyan's patent, or the injection of a solution of the chloride of mercury. 2. Margery's process, or the injection of a solution of the sulphate of copper. 3. Sir William Burnett's process, or the injection of the chloride of zinc. 4. Payne's process, or the production of a double decomposition in the pores of the wood, by firstly injecting a metallic solution, such as the sulphate of iron, and then injecting a second solution such as the carbonate of soda, which would form an oxide of iron in the cellular tissues. 5. Bethell's process of creosoting, or the injection of the heavy oil of tar; and Boucherie's process, which is, perhaps, rather a modification of the manner of injecting the sulphate of copper than the application of a new solution, although he occasionally uses the chloride of calcium, and the pyroliguite of iron. The experience furnished by the railway system, and the various hydraulic works of our own and foreign countries, appears to me to have shown that the efficacy of those various processes may be described as follows:—The creosoting one is the most generally successful; the application of the sulphate of copper is successful in many cases: the other processes, although no doubt of occasional value, have practically been abandoned. It will, therefore, only be necessary to revert to the creosoting process, and the use of the sulphate of copper.

Now the application of any of the aqueous solutions of mineral salts as a preservative process, seems to me to be of limited benefit in cases where the wood is exposed to the action of frequently renewed water, for it has been proved, practically, that the combination between the salt and the albumen is not sufficiently permanent to resist the long-continued solvent action of such water. For piers, bridge foundations, or dock-work, or even for railway sleepers, I myself should hesitate to use any of the mineral salts; but for house-building purposes I think that there cannot be any reasonable doubt of the beneficial effects of the application of the sulphate of copper for the prevention of rot in its various forms, and I should decidedly recommend its use for the timbers of ships not immediately exposed to the action of the water, whether the timbers be or be not seasoned. It is also to be observed that the solution of the sulphate of copper does not communicate any disagreeable smell to the wood, an objection which applies forcibly to creosote, and the former process may, under such circumstances, be adopted for domestic purposes. The proportion of the sulphate of copper in the solution should be 1 lb. of the salt to 4 gallons of water.

In addition to the objection to the sulphate of copper, and the other metallic salts, on the score of their solubility in running water, there is this peculiar objection to them in the case of timber used in sea-water, viz. that the action of the albumen in the wood renders them perfectly innocuous to animal life, however poisonous they might originally be. Wood thus treated is not, then, in any way protected against the timber-destroying insects, whereas it is certain that the injection of creosote is a most effectual protection against some of those creatures; for you may observe that in the section of a pile exhibited the *teredo* has gone out of his path to avoid the portions of the wood impregnated with that substance. In India it seems also that the white ants have a dislike to creosote, and they avoid wood which has been prepared by its injection; so that inasmuch as the experience of nearly twenty years has shown that the ordinary causes of decay are arrested by this process, and that it affords an effectual protection against many timber-destroying insects, it seems to me that wherever the peculiar odour of creosote does not constitute an objection to its use, it should be applied. I beg, however, distinctly to call attention to the fact that I do not assert that creosote will protect wood against all descriptions of boring worms, for samples of wood said to have been creosoted have been occasionally shown which exhibit traces of the ravages of the *limnoria terebrans*. I think that much reason for doubt exists on this matter, because in far too many cases the creosote used has been of inferior quality, and in many others the pyrolignite of iron has been substituted for it. I have not been able to analyse the samples of the prepared and attacked woods I have seen, but I am very strongly inclined to question whether any authenticated cases of the failure of creosote really exist. The asserted fact of the attacks of the *limnoria* is, however, a very remarkable phenomenon under any circumstances, and it merits very serious inquiry by our scientific and technical bodies. If the pieces of wood in question were really creosoted, it would seem to prove that the material which is distasteful to one animal may be attractive to others, and therefore the green-heart timber, which is said on very doubtful authority to be protected from the *teredo* by the essential oil it contains, may be exposed to destruction from the *limnoria*, or from the land insects I have myself noticed in it. If the piece of wood just referred to were prepared by the injection of pyrolignite of iron, it would equally seem that that ingredient is no more capable to protect wood against insects than it is admitted to be able to protect wood against rot or decay. There are several very obscure points connected with the habits of the marine boring worms which I am at present studying, and I hope on some future occasion to be able to dwell more at length on the subject. My present impressions are, that these dreadful pests have peculiar habits, that is to say that they respectively select the localities for their residence on account of some peculiarities in the chemical composition of the materials of the sea-shore, and that they have peculiar and distinct tastes, so that the immunity from the attacks of one of the classes of insects does not necessarily imply immunity from the attacks of others. But as the *teredo* is the most destructive of the marine, and the white ant the most destructive of the land, devouring insects, it seems to me that the process of creosoting (which is now generally admitted to be an effectual protection against both of those enemies) should be adopted in all cases where wood is likely to be exposed to their attacks. That creosote is able to protect wood against ordinary decay is proved by the state of the sleepers of some of our railways laid down as far back as 1841; but of course this process, like all practical chemical ones, requires to be skilfully and conscientiously applied. Much prejudice against the use of creosote seems, for instance, to have been created by the decay of timber treated by the pyrolignite of iron, and still more by the shameful manner in which the creosote itself has been used, for in the section of the pile on the table no more of that oil is to be found in the wood than the latter would be able to take up by a very temporary immersion. In the best creosoting works, such as those of Mr. Bethell, or the still more extensive ones of Messrs. Burt and Co., the oil is injected at a temperature of 120 deg., and under a pressure of 150 lb. on the square inch, so that ordinary fir-timber absorbs on the average from 8 to 10 lb. weight of the creosote to the cubic foot.* For all building or hydraulic engineering purposes, fir-timber thus treated is far more durable than the best oak, teak, or other hard woods; and as the cost of the operation is

* All these methods of protecting timber from external and internal sources of destruction depend for their success upon the skilful and conscientious manner in which they are applied; for, as they involve chemical actions on a large scale, their efficiency must depend upon the observance of the minute practical precautions required to exclude any disturbing causes. The purity of the salts or of the creosote used, the strength of the solutions, the treatment of the wood before the injection of the preservative materials, and the manner in which those materials are injected, all require strict attention, and they certainly render it necessary for the engineer or architect either to resort to those establishments which have a good reputation to lose, or to exercise the most rigid personal supervision. Anyone, in fact, who would examine the creosoting works of Messrs. Burt and Co., the largest I have seen near London, must be convinced of the necessity for these precautions, and it will suffice to observe the great practical skill, the care and attention with which in those works the creosote is distilled, the sap or other moisture drawn from the wood, and the fluid subsequently injected, to arrive at the conclusion that operations of this kind should only be carried into effect by experienced persons of high character. The machinery required for preparing a long stick of timber, of considerable scantling, is in itself a very serious matter, for it is necessary in the first place to make a vacuum which should allow the sapwood to escape, and to do this in cylinders of 6 feet in diameter, and from 20 to 50 feet in length, is in itself both difficult and dangerous; then the injection of the creosote at a temperature of 120°, and under a pressure of 150 lb. on the square inch, is, as every practical man knows, a dangerous operation, requiring skilful manipulation and costly machinery.

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very small, it should certainly be resorted to on all occasions where the smell of the creosote is not likely to be objectionable. When this is the case, I certainly think that some modification of Margery's process should be adopted, and that house or ship timbers exposed to damp, warm, and confined air, should be treated with the sulphate of copper.

THE GUESTEN HALL, WORCESTER.

THE fact that this beautiful relic of mediæval skill,—unique perhaps of its kind,—after being allowed. through centuries of neglect, combined with other causes, to lapse into a most pitiable state, should at last, in this nineteenth century—this age of archæological conservatism—be threatened with entire demolition, is a circumstance so outrageous, that zealous protests and active measures are being employed in all quarters to avert the disgrace which so barbarous an act would entail upon not merely the city of which this "hall" was once so great an ornament, but also upon the country at large. It might seem that an ill fate betides it yet, unless the endeavours now making are promptly seconded; and it is therefore with a view of acquainting such of our readers as may not be familiar with the building itself with its leading and most interesting features, that we here introduce the subject, and hope to enlist their sympathy on its behalf.

The existing records of this building, a portion of the ancient monastic establishment of Worcester, are comparatively few and indefinite; its name however is suggestive of the purpose to which, in all probability, it was devoted, viz., a separate hall for the entertainment of guests or strangers; and in Green's 'History of Worcester' it is stated, that "there remains one public office of the old monastery that may give us some idea of its original hospitality. This is the Audit-house, anciently called Guesten Hall, built in 1320 by Wulstan de Braunsford, then Prior and afterwards Bishop of Worcester, for the entertainment of strangers exclusively, the rules of the order not allowing them to sit with the monks at the tables of the refectory. In this hall the convent held their monthly court, called the Guesten Hall Court, for the determining of differences between their tenants; and it was a custom preserved even to the days of Charles the First, that the tenants of the church might not sue each other in actions for less than 40*s.* in any other court but this." In the Parliamentary survey is the following account of some of its customs: "There is a court leet and court baron belonging to this manor, where the tenants are bound to appear, as well leaseholders as copyholders: the freeholders hold by fealty and rent."

The Guesten Hall, one of the most beautiful examples of Mediæval Domestic Architecture of which England has had to boast, is on the south side of the cathedral, and within its precincts, and stands north and south. Internally it is 65 ft. 8 in. long by 34 ft. 11 in. wide, and 36 ft. 8 in. high, from the floor to the top of the wall-plate. The roof is divided longitudinally into eight bays, and constructionally consists of principal and common rafters and purlins, a collar to each truss, and struts above the collar, which are arranged so as to form a centre quatrefoil, and trefoiled spandril spaces. There are three purlins on each side, and a centre ridge, all of which are moulded, and the wind-braces (also moulded) in front of the common rafters are sub-arcuated, and have tracery. Below the lowest purlin, each bay of the roof is subdivided into two by a subordinate rib, each division having an ogee-head and cinquefoil tracery. The wall-plate is moulded, and supporting each truss is a small shaft with mouldings on each side, which mitre with those of the wall-plate, terminating in stone corbels, a few of which still remain, in which the design is in each instance varied, and which exhibit considerable merit in the sculpture. The windows were originally nine in number, viz., five on the east and four on the west side of the hall, the south-west bay being occupied by the entrance porch, and were all two-light, the heads being filled with elaborate and exceedingly graceful tracery; the two at the north-east of the hall are shorter than the rest below the springing, a low range of buildings communicating with the hall having existed beneath them. The windows were very lofty, and in all probability were transomed.

Like many domestic buildings of similar or subsequent date, the hall does not appear to have had a fireplace; and some indications are yet discernible of a louvre in the roof for the escape of smoke from the fire, which probably was kindled on the floor of the hall. The upper or north end of the room, where the dais stood, was covered to the height of about 12 feet with painted mural decoration, consisting of a diaper of quatrefoils with a shield in each, above which were painted a series of subjects. Externally, one especial feature, similar to that which exists at Penshurst in Kent, and Mayfield in Sussex, was observable in the segmental arches over each window between the buttresses, the constructional value of which arrangement consisted in the additional thickness thereby given to that portion of the wall, to receive the weight of the roof which was thrown on the buttresses, and thus relieved the pressure over the windows.

The south front, which is the one most seen, has been so mutilated and disguised, that no one would for a moment imagine the treasure to be seen within, though the clearing away of a house built against it has disclosed among other fragments the jamb of the original porch. The building is stated to have been erected in 1320, but the character of the window tracery, the woodwork and mouldings, is of a somewhat later period. Probably it was commenced in 1320, but not completed for some years after. For much of the foregoing description we are indebted to Messrs. Dollman and Jobbins' 'Analysis of Ancient Domestic Architecture,' in which the subject is fully elucidated, and the architectural details of the building clearly shewn in a series of excellent plates.

There remained, even up to the present age, another building of very similar character, viz., the great hall of the Abbey, at Great Malvern, not far distant, of which not a single trace now remains. Here the woodwork was of the boldest and richest kind, in the roof especially, where all above the tie-beam was a mass of tracery, in cinquefoils, trefoils, &c.; the wind-braces under the purlins being also similarly cusped. If the Guesten Hall has hitherto escaped the doom of its neighbour, it would seem to be more owing to good luck than good intention. For, as if to compensate in some degree for the forbearance which the men of the 15th and 16th centuries had displayed towards this building, the men of the 17th and 18th—barbarians in point of taste, and niggardly economists in all their dealings with ancient memorials—proceeded at various times, apparently, to cut up this precious monument of their forefathers' art and hospitality into a great number of small rooms, by a series of floors and subdivisions; the said walls and floors ruthlessly intersecting or abutting against the quaintly-devised corbel, or the delicately ramifying tracery of the windows, and leaving a glimpse only of the glories of the timber roof to be seen from the upper end of the Hall, which in process of time was converted into a brewhouse, and a store-room for faggots and fuel, it having in the course of the last century been partially converted to the uses of the deanery. Not satisfied with this destruction of the interior, a portion of the southern end of the roof was cut off, and the lofty gable of the ancient south front (before referred to) was replaced by a flat, square, and hideously ugly front, so deformed and entirely wanting in any kind of respectability, even of appearance, that one wonders more and more at the fatuity of men who could build it.

At present, we believe that certain portions of the internal additions are in process of removal, revealing the deplorable condition of the roof, and its possible insecurity: indeed, the task of restoration, if determined on, must now involve great labour and expense, but this should not weigh against the worthy object of preserving so notable a specimen of art. The question as to the uses to which the place might now be devoted, is one into which we are scarcely called upon to enter, although it is one which is causing some discussion in certain quarters. To devote a noble building to menial purposes is at best unsatisfactory; but to retain it that it may be so employed for a few days only in each year, while for the rest it lies vacant and uncared for, is an abuse that will find little favour in an age so eminently practical. Diocesan societies would find in it a suitable place of meeting; or it would be a very serviceable place for lectures, and especially as a practising school for ecclesiastical music, whether for amateurs or for the choir of the adjoining cathedral. Nor would it be difficult to mention other cognate purposes, provided the dean and chapter do not discover for it, as surely they might, some more appropriate use in connection with the cathedral itself.

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THE ISTHMUS OF SUEZ NAVIGATION PROJECT, CONSIDERED IN REFERENCE TO THE PHYSICAL IMPEDIMENTS TO ITS REALIZATION.

By W. A. Brooks, M.Inst.C.E.

(*Concluded from page* 173.)

Even in the system of an open cut the promoters have seen the necessity of a supplementary canal from the Nile, extending from sea to sea, and from the proposed port of Suez to that on the shores of the Mediterranean,—there being a total want of fresh water in the Isthmus.

As regards the main difficulty, that of keeping open a communication between the two seas, the author's only fear is as respects that between the canal and deep water in the Mediterranean; because on the Red Sea side the canal may be made to debouche into a good port on the Asiatic side, a few miles south of Suez, the entrance of which would be kept clear by the natural tidal scour from the head of the bay; or the canal may be made to debouche into the Red Sea on the opposite or Egyptian shore, where very deep water is found at a short length, and where there are no surrounding sandbanks likely to peril the success of the undertaking, as per plan of the International Committee adopted by those gentlemen for the port of Suez.

The author regrets that he cannot hold out the slightest encouragement as to the possibility of keeping open a channel between the canal and deep water in the Mediterranean, because of the existence of the current which continually sets along the northern shore in an easterly direction, bringing necessarily with it the whole of the alluvial matter discharged from the mouths of the Nile, and also whatever is by on-shore gales raised from the bed of the sea.

The borings, taken with great care, and which to the credit of the Committee have been faithfully published, show nothing of a reliable nature also on which any superstructure of weight (such as the proposed piers) can be based, or through which a deep water channel could be cut, without providing very much larger slopes than as proposed, and of course entailing a vastly increased outlay. The slopes proposed are two to one, but the author in his experience has found that three to one are necessary even in good alluvial land; and he is of opinion, that where the proposed cut passes through the formation produced by the deposit of the Nile, the slope should certainly be four feet horizontal for every foot in depth of the cut, and even then the spoil-banks ought to be separated from the margin of the cut by a wide fore-shore or quay.

In the event of the piers being completed, notwithstanding the great difficulty of the softness of the formation upon which they have to be constructed, there will still remain the great difficulty —the opprobrium of the project,—that of being able to repel the intrusion of the drifting sand and mud, which the author believes will be found to be so vast in extent as to be incapable of being surmounted by any dredging power likely to be applied. Few know how great is the difficulty of dredging, even in an exposed channel of a river; and how rare it is to find the sea in a fit state to allow dredging operations to be carried on, even where the prevailing winds are not on the shore; but on the northern coast of the Isthmus the difficulties will be greatly increased, on account of the prevalence of on-shore winds.

There is again one other great natural obstacle to the realization of a deep-water approach from the sea by the protrusion of piers, and that consists in the alteration of the bed of the sea which would be sure to attend the new feature given to the coast by the extension of the piers beyond it. The angles between the piers and the shore line would rapidly fill up, similarly to that which now takes place simultaneously with the protrusion of the channels of the Nile, and the pier-head would become nothing more than any natural projection of the coast; and the contour lines of soundings would in like manner be regulated by the back sweep of the wave producing an incline of the shore, according to the nature of the material of which the bed of the sea consists. The pier-heads would therefore have to be continually extended seawards, simultaneously with the alteration which would take place in the depth of water in their vicinity. Looking therefore at the enormous cost which must attend the experiment of making and maintaining a deep-water connection between the canal and the Mediterranean, the author is impressed with the conviction that the soundest view to be followed is that proposed by M. Paulin Talabot, viz. to connect the canal with the Nile, and from thence with the magnificent port of Alexandria.

In the reviews which have been published of M. Talabot's plan the author is of opinion that that gentleman has not had justice done to his proposition, which was to cross the Nile at a level,—which appears in point of outlay to be very much under the cost of forming a direct cut and its supplementary fresh-water canal. The reviewers have directed their energy against the more complicated alternative plan of M. Talabot, of crossing the Nile by an aqueduct, which that talented engineer has (in the opinion of the writer) advanced to satisfy those inexperienced people who will not allow it to be practicable to cross the Nile at a level. The latter plan may be effected either above or below the barrage; the position below being however more certain of insuring a continuance of deep water, as the head of water above the barrage will enable sluicing operations to be carried out to an extent which will be sure to produce a pool below the barrage, and below its apron, having sufficient depth of water to allow vessels of the largest draught of water to pass between the entrance locks on either side of the river.

By the project of M. Alexis Barrault, of a canal carried in a line across the lakes near the Mediterranean, it appears that the Nile in its natural state affords a sufficient depth in some parts of its course to enable it to be traversed by vessels of the largest draught. M. Talabot's scheme passes however over firmer ground, or the line taken by the ancient canal between Suez and Bubastis, and interferes less with the great drainage of the Delta.

M. Talabot's design would have been possibly of still easier realization if the barrage had been made across the Nile above its first bifurcation, instead of immediately below it. This interesting work has been undertaken by the Egyptian government, under the advice of an able French engineer, M. Mongel, and is destined to retain the waters of the Nile, so that there shall no longer arise those periodical famines produced by the floods of the Nile not reaching to a height sufficient for the purpose of irrigation, on which the agriculture of Egypt altogether depends. The height of the flood, measured by the Nile gauge at Cairo, varies between 5 metres (16 feet) and 9 metres (29 feet). All floods below 5·40 metres producing famine, and equally so those are which attain the height of above 8 metres,—the mean of the two giving abundance. Any interference with the regime of the Nile must evidently therefore be treated with extreme caution.

The dam or barrage of the Nile crosses the Damietta and Rosetta branches about 12 miles below Cairo, leaving a passage for the Damietta branch of 543 metres in breadth, and for the Rosetta branch of 492 metres, with the addition of eastern, western, and central canals, provided with locks, immediately above the barrage. The aprons of the Damietta and Rosetta branches of the Nile have been placed at the level of 10·41 metres above the level of the Mediterranean sea, or 1·61 metre below the zero of the Cairo Nile gauge, the top of the barrage being 20 metres above the level of the Mediterranean, and 8 metres above the zero of the Nile gauge. No doubt remains in the author's mind of the ultimate effect of the completion of the barrage of the Nile being that of establishing deep pools both above and below the same, so that a sufficient depth will be procured to enable both branches to be easily traversed by ships making use of the canal; possibly even without the assistance of any dredging power, but certainly without requiring more than the occasional assistance of a single machine, in deepening the small space of about 500 metres in breadth between the two branches of the Nile, or abreast of the apex of the bifurcation; and as the formation of a canal in the course proposed by M. Talabot is merely a repetition upon a larger scale of what has long since been executed over nearly the same ground, the subject need be no further discussed, and it remains for the author to give some further explanation only of the harbours which he has before alluded to as capable of being constructed at the head of the Red Sea, without being liable to be silted up, like that which has been proposed immediately in connection with the canal at the town of Suez, which occupies the central position of the three outlets for the canal as shown on the chart.

In preference to the central harbour, or that adopted by the International Committee, the author has delineated an extension of the canal along the eastern shore of the Red Sea to the first rocky headland south of Suez, called by the Arabs, Kar el Machrour. The foreshore of this headland consists of limestone, which falls rapidly into the deep-water channel, which is kept open by the tidal scour, and which will therefore b out of dan-

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ger of being diminished, as no alteration will be necessary which will interfere with the present course of nature. The depth at this point is 10 metres at a distance of 700 metres from the margin of the shelf of rock before alluded to; whereas, to reach the same depth as per International Committee's adoption, the piers must be of a length of 4000 metres, and they will be in the latter instance placed so as to insure the destruction of the port they were meant to create. They are, in fact, just what the author would carry out if it were his intention to warp up the head of the bay of Suez.

The preferable site for a Red Sea port is however to be met with on the western or Egyptian coast, about the same distance from Suez, and abreast of the Mount Ataka limestone range, and 4 miles south-west of the Red Sea port proposed by M. Talabot for his ship canal. At the site proposed by the writer a depth is to be met with of 28 feet at the short distance of 550 yards from the shore, and of 42 feet at 1095 yards. This harbour would be safe to take with any wind, and of capacity sufficient to hold a large fleet, and possess such tranquility during all winds, that it would in the author's opinion be of immense value to the existing commerce if it were at once constructed, and the present railway extended to it. An outlay of about £50,000 on a pier formed from materials procured from Mount Ataka limestone quarries, and an extension of only five miles of the present railway would prevent the necessity of the tedious transfer of passengers, luggage and merchandise from the railway at Suez to the steamers in the roadstead which now takes place by means of small craft.

The author of this paper sat down to it with the hope of offering an useful review of a measure which, if it could be carried out, would confer a greater boon upon England than upon any other nation foreign to the country through which the canal would pass; and he can, on the part of his countrymen, refer to the vast works which they have executed in foreign countries by their unaided enterprise and capital in many instances, as proofs that measures have only to contain in themselves sound elements of utility to insure their co-operation as individuals; and, in a work which might be shown to be of national utility, England would not be the last among the nations of Europe to give even the strength of her support as one of that great national community. With this view the writer has, he trusts, discussed the subject in a spirit devoid of petty professional criticism as to matters of detail, as to the cost of the works, or of their maintenance when executed. It has been no part of his duty to calculate whether the work will be one which will prove remunerative to those who have to provide the capital, because that is a duty which falls upon the promoters and their engineers; and it forms no portion of the investigation on the part of the author whether the realization of the Isthmus of Suez navigation will cost many more millions sterling than as set forth by its promoters; the object of this communication having been simply to grapple with the difficulties of a physical nature with which the subject is surrounded, and to endeavour to point out how best they can be surmounted.

Although the author is of opinion that it is practicable to form a ship canal between the port of Alexandria and the Red Sea, he is not prepared to advocate it as a measure which would be worthy its cost as a commercial enterprise, or the risk which it would entail upon the agricultural prosperity of the vast fertile district through which it would pass for a great portion of its length. Before venturing to give the recommendation of his humble opinion on a subject of such magnitude as a ship canal of above 240 miles in length, a long and careful local investigation would be necessary, and his mind would also have to be satisfied of the practicability of obtaining the full depth required at the port of Alexandria. That port, in its present condition, does however possess sufficient depth of water for ships of moderate draught, although not adequate for the reception of vessels of the largest class. It must also be remembered, that, although the present communication by railway between Alexandria and Suez has a fair prospect of successfully competing with any other route to the East, it must nevertheless also be borne in mind, that should that route be burthened with the vast expenditure of a ship canal, it would have less chance of being able to encounter the rivalry of the more direct route by the valley of the Euphrates, which would be that of the hypothenuse to the other two sides of the triangle formed by the course down the Red Sea and along the southern shore of Arabia.

It may not be out of place to notice here, that in addition to the line commencing at the mouth of the Orontes, as originally propounded by the promoters of the Euphrates Valley Railway scheme—which labours under the defect of an exposed coast, on which an extensive artificial harbour must be formed, the Orontes being useless as regards navigable purposes—a more direct line, proposed by the author, may be followed, commencing on the coast abreast of the island of Ruad, 150 miles south of the Orontes, from which the head of the Persian Gulf may be reached by a course of 800 miles, terminating in a deep-water harbour, clear of the bars which are situated at the mouths of the Euphrates or Tigris rivers.

Ruad island now shelters an extensive roadstead, having from 5 to 7 fathoms at low water, for which a large fleet may safely run in the heaviest of on-shore gales; and which may by the outlay of less than £100,000, in raising the reef on the south of the island up to a few feet above the surface of the sea, be made to hold all the line-of-battle ships afloat in the Mediterranean, or several hundred sail of merchant vessels. The island, which is about a third of a mile in length from north to south, consists of sandstone, from which blocks of any weight may be quarried for the purpose of raising the reef to a higher level, or converting the same into a mole or pier. The island is destitute of water, but between it and the mainland three submarine springs exist, which in calm weather rise above the level of the sea, and from which fresh water is now procured, as in the time when Strabo noticed them. They are situated in a depth of about four fathoms water, and of course are supplied from the mainland, where abundance of water can be readily obtained.

It was the original intention of the author to have confined his observations to a detail of those physical conditions upon which the success of the experiment of making a cut through the Isthmus altogether depended. Those features the author considers are dependent upon the difference of level existing between the two seas being sufficient to maintain a current of that velocity which would be capable of keeping open a passage or channel through the shoal water of the bay of Pelusium, or of counteracting the effects of the prevailing winds and eastward current in bringing into the bay the vast alluvions of the Nile.

If there had existed a sufficient difference of level between the two seas, it is only reasonable to infer that the promoters of the Isthmus of Suez open cut would have advanced it as a fact which would guarantee the success of the work. With a head of water which would have insured a powerful current through the connecting channel there would have been no danger of either the channel itself, or its approaches from either sea, being encumbered by sandbanks or by the alluvions of the Nile; and M. de Lesseps and his supporters would have had only to refer to the velocity of the current which must have existed with that head of water, to save themselves the trouble of suspending the operations of nature, by assuming that the alluvions of the Nile have ceased, since the time of Strabo's visit to add to the Delta which they have already produced to the extent of above 3600 square miles.

The promoters of the project, although they were well aware that the difference of level between the two seas was so small as to be unable to maintain a powerful current through the channel to keep it clear of deposits of sand and mud, have however failed to make public the true state of the case. M. de Lesseps and his friends have left it to others to state for them how inadequate is the difference between the mean levels of the two seas to give that velocity to the current through the channel which is essential to prevent the latter being choked up.

As however M. de Lesseps and other friends of the Isthmus of Suez project have passed over the momentous question of the velocity of the current, and have based their expectations of its success upon their belief that the alluvions of the Nile have ceased to have any influence in filling up the bay of Pelusium, or in causing accretions on the shores of the Delta, the author recommends the study of the able investigations on this subject by Capt. Spratt, of the Royal Navy, which were ordered by the House of Commons to be printed on the 9th of February last, but from which only a few extracts will now be given of M. de Lesseps' reasonings and arguments on the practicability of the Suez Canal, and the opinion which Capt. Spratt has arrived at on the same subject:—

M. de Lesseps says: "Now it appears that for many ages the sands have ceased to extend the Pelusiac shore, as is manifested from the well ascertained position of Pelusium, the ruins of which still remain. Strabo, in his 'Itinerary,' says that Pelusium is

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situated at the distance of 20 stadia from the sea; the French engineers of the expedition have verified this distance by measuring 1600 toises or 3000 metres from its remains to the shore. In 1847 the distance between these two points had not varied, as it is marked on the plan with the figure 3000 metres; and at the present day it is still the same. In fact, by reading all the accounts of ancient authors, and comparing them with what actually exists, we arrive at the conclusion that the shores of the Delta have varied very little in historic times. The sea sands, then, have long ceased to accumulate, and the fact may be explained by assuming that the destruction of the coasts of Morocco, Algeria, Candia, and other parts—which destruction, we repeat, alone furnishes the materials of maritime alluvium—has abated from some cause or other. It may also be assumed that the sands which were formerly driven by winds and currents into the gulf of Pelusium, are now cast on the African coast, between Tripoli and Alexandria, and driven inland in the shape of downs. The fact is, that no new downs are now seen forming on the Isthmus, those on the sea-shore being of ancient formation, and nearly all naturally fixed by vegetation. In conclusion, the extension of the Pelusiac shore, if such extension there be, is too insignificant to be taken into consideration."

Capt. Spratt, in reply, observes—"On inspecting a chart of the coast, it will be seen that the coast and shallows off Alexandria are for the most part rocky, and not sand, as M. de Lesseps states; and so is the greater part of the coast to the westward as far as Cyrene, being formed of rocky headlands and a rocky shore line, that are the roots or salient prongs of mountain ranges. For Alexandria, or rather Abu-kir Castle, stands upon the termination of this rocky shore, which once no doubt jutted out into the sea as a long peninsula of land, being elevated from 50 to 100 feet above it. And immediately off and to the westward of Alexandria the sea is deep, there being upwards of 100 feet in depth at only 2 miles from the shore; whilst off the bay of Pelusium that depth does not exist nearer than 20 miles; so that this fact at once indicates that in advancing to the westward of the Nile, we are departing from the true origin of those vast shallows and sandbanks which extend off the coast, and form the Suez isthmus and the Nile delta. Thus the coast-abrasion theory of M. de Lesseps is at fault—an evident fallacy at the first step of the investigation on the line from whence he attributes the ancient origin of these accumulations, viz. from Tripoli and Morocco. And besides, if the coast line is contemplated with an engineering eye and view, it will be seen that with the prevailing winds and currents the rocky tongue of Alexandria ought really to have checked such littoral movements from coast abrasions, being a sort of natural groyne to cause a stop there, from its extending out in a direction about north-east, and therefore at right angles to the wave movement or prevailing ground swell. This explains why Alexandria has not filled up by the little abrasions of the coast that, no doubt, for ages have occurred to the westward of it."

Captain Spratt thus again proceeds, after alluding to the Nile's influence:—"Hence also the cause of the elevated accumulations along the belt or cordon of sand which extends from Pelusium for 50 miles towards the Syrian shore; also of the numerous shoals and ridges of sandbanks which have accumulated off that coast, and seem to be the nuclei of a future cordon of sand, which by their connection will eventually form outside of the present one, so as to inclose a new lagoon within it. Therefore, with all these facts regarding the accumulation of matter, the origin of which is thus traced to the mouths of the Nile, the effect upon piers placed so near its source, and so much more transverse to the movement than the Kas Burún shore presents, must be evident. For in my humble opinion, as the shingle at Dover beach at times mounts over its elevated groynes, so will the sands from the Nile mount over the piers of port Saïd, and more easily than they have mounted up to form the steep hill of Kas Burún, at an elevation which overtops the loftiest ships. For that remarkable elevation of the sandy ridges, extending eastward of Pelusium to Syria, and reaching their maximum at the hill of Kas Burún, although so far from the Nile, is the evidence of the quantity of its deposited, advancing, and dispersed sands,—the answer to its supposed negative influence in Pelusium bay and proximate coasts. It is necessary and just to the commercial interests desiring to embark in the project of M. de Lesseps, to know these important facts ere they risk their millions in the undertaking, instead of discovering them only when swamped in the sands they will have to contend against; and then to discover also, when too late to amend it, that Alexander the Great was wiser than M. de Lesseps admits, when he listened to the local opinion regarding the influence of the Nile upon his harbour if formed to the eastward of it. At least, with all due deference to the judgment of that able gentleman, the above facts, and my hydrographic experience of the Mediterranean, extending over a period of twenty years, teach me to believe so."

In another report Capt. Spratt strictly investigates the correctness of the assertion, "that the shores of Pelusium have not advanced since the earliest historic times," from the supposition that the existing ruins at Farama were those of Pelusium, and that the ruins at Farama are stated to be about the same distance from the sea that Pelusium was said to be in the days of Strabo. Capt. Spratt shows, firstly, that by his own measurement the ruins of Farama are even now at a much less distance from the sea than the Pelusium of Strabo, viz. at only 1½ mile from the shore.

Secondly, that the ruins of Farama are the ruins of "the city of Ferma of the middle ages and of the Coptic authors; as also the Pharamia of the Crusaders, lying on the borders of Egypt and the sea-shore, which Baldwin took by surprise in 1118, but, falling sick immediately after, could not extend his conquest into Egypt, and therefore returned to Jerusalem, and died. And that this Pharamia or Farama, and Pelusium, were distinct cities is also shown in Michaud's 'Croisades,' liv. x.—"Vers le mois de Fevrier 1118, il (le roi Baudouin) assembla l'élite de ses guerriers, traversa le désert, surprit et livra au pillage Pharamia; située à quelques lieues des ruines de Thanis et de Peluse." Thus Farama is distinctly indicated as a city upon the sea-shore, and separated "several leagues" from the ruins of Pelusium; that is, eleven centuries after Strabo; and it seems from these extracts that it was then near an outlet from the lake of Tennis, or branch of the Nile, and called the Canal de Tennis in consequence; similar, in fact, to Foum el Fareg when it was an outlet from lake Menzaleh, a century ago.

Thirdly, the ruins of Farama are shown to be of comparatively modern construction to those which must have existed at the Pelusium of Strabo.

Capt. Spratt then shows that by the 'Itinerary' of Antoninus, Pelusium was only 13 geographical miles from the city of Daphne, on the route to Memphis, and that Daphne is clearly identified at some ancient mounds near the mouth of the most eastern, and therefore the old Pelusiac branch of the Nile, from the mounds retaining the name of Daphne or Tephne still, although the place is uninhabited; on referring to it, the natives of the shores of the lake knew its position well, and pronounced it Tephne. The same place is referred to by Herodotus as the "Daphnæ of Pelusium," showing that it was under it, and therefore in some degree proximate to it. The same situation is also assigned to Daphne, and is so called, on the chart published by the International Committee. Capt. Spratt made a laborious investigation of the district, which ended in his finding extensive ruins and coins, apparently of the Ptolemaic and Roman times, and also according with the distance assigned to it from Daphne, or Tephne, viz. about 13 geographical miles.

Abookhiar or Abukir, where these ruins were discovered by the expedition under Capt. Spratt's orders, consists of a mound nearly a quarter of a mile long, somewhat less in breadth, and about 30 feet high, and has nearly a flat summit. "The mound is chiefly composed of loose sandy earth, and fragments of crumbled brick and pottery, with some fourteen or fifteen widely detached and crumbling blocks of granite, besides limestone and sandstone scattered over it, none however very large, and no columns, yet sufficient vestiges altogether to show that the site was ancient and of some importance in early ages, and evidently of a more ancient character than any mound in the neighbourhood. The native traditions assert it to be so, and it is also confirmed by the coins found about, which are apparently of the Ptolemaic and Roman times, by their size and thickness, one or two being of the larger sized Ptolemaic coins. No Arabic coins were procured from it. It seems also confirmatory evidence that to the south-west of Aboukir there is another mound; some substantial building once evidently occupied the position, for it has fifteen or twenty squared blocks of white limestone, and a squared block of white marble lying on its surface, besides a black slab of porphyry hollowed for some domestic or special purpose; crumbled brick and pottery, with coins of the larger size and earlier Ptolemaic form, although all obliterated, are also scattered over the surface, and together make up the evidence

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that this little mound also is not of modern times. Notwithstanding however that a dead level swampy plain separates the two, yet the imagination is much disposed to say, Here are the two extremes of Pelusium! for what that plain of soft mud between and to leeward of them may contain of the buildings that may have united these probable extremes of a town like Pelusium, none can discover; especially as the filled-up channel of the Pelusiac branch is there also, or between them, if it divided the two fortresses of Pelusium, as Dr. Brugsch represents; and thus the two mounds may identify the actual fortresses."

The author has purposely avoided expressions of the opinions of eminent English engineers on the subject of this paper, and especially in reference to the conclusion which was arrived at, after careful local examinations of the site of the proposed works, by the late eminent Robert Stephenson, whose professional opinion was so much esteemed for its ability and integrity.

ON THE ARCHITECTURAL CAREER OF THE LATE SIR CHARLES BARRY*.

By M. Digby Wyatt.

Of such men as the late Sir Charles Barry it is occasionally said that they cannot be rightly appreciated in their own generation, and that it is not until intervening time may have as it were permitted "the mind's eye" to recede sufficiently to be enabled to embrace generalities, and blend them according to proper pictorial conditions, that the relations of such men to the circumstances by which they may have been surrounded can be justly estimated. Of the philosopher, legist, politician, and of the hero who dominates in the feverish turmoil of class against class or nation against nation, this observation may frequently hold good, but of the great artist comparatively rarely. His creations are of an essentially monumental character, and it has scarcely ever occurred that the author of works commonly known at the date of their execution, and ultimately accepted by the universal verdict of posterity, has failed to be recognised by his own generation, and certainly by cotemporaries in his own profession, at his approximate value. There is in fact no more distinctive and vital characteristic of true art than its universality. Really creative power is neither for this time nor for that class, but for all time and for all classes,—for the present as for the future, and for the future as for the present. The poet, the painter, the sculptor, the musician, the architect, appeal in their highest efforts to sympathies, aggregate as well as individual. From this inherent condition of universality in all great works of art emanate three especial bonds of union and affection:—Firstly, between genius and the world at large; secondly, between genius and all who, however devoid of it, may be endeavouring to achieve success in the same department of art; and thirdly, between genius and kindred spirits of all ages, who in pursuits of the most widely differing natures have reared their heads aloft above the average of mortality, and won admission to the noble brotherhood whose names have become landmarks in the history of civilisation. In the death of every great artist these bonds receive a sudden shock, which, however it may jar and strain, can never break them. There can be no higher tribute to the ascendancy of genius than this impotence of death itself to finally sever bonds of union between mind and mind, which it can only shatter; and it is the very measure of this impotence which affords the best scale for ascertaining the nature, force, and amount of the loftiest order of human creative power.

Let us for a moment apply it to the case of the friend we have lost, and try his memory by the three bonds described as at once the essential tests, concomitants and rewards of genius, contradistinguished from mere talent, industry, and experience.

In the first place, can the world at large cease to esteem the designer of the Houses of Parliament, the Reform and Travellers' Clubs, Bridgewater House, Cliefden or Trentham? Surely, to this the only answer can be,—Yes, when they have forgotten Sir Christopher Wren and Inigo Jones, Bramante, Claude Perrault, and Palladio; and not till then. In the second place, can we, as architects, or can they who may succeed us when we shall rest from our labours, as our friend now rests from his, cease to regard with interest and admiration the models for study bequeathed to our art in monuments such as those, on the production and perfection of which his most strenuous efforts were concentrated? Surely never so long as architecture remains a fine art, based on any recognised laws of symmetry, eurythmia, fitness, and proportion, can we fail to appreciate works in which (whether under a more or less classical or mediæval garb) the true importance and indeed indispensability of a rigid, but at the same time free, subordination to those laws, are more ably vindicated than (according to my belief) in the works of any other architect who has lived for at least two centuries! Can, in the third place, Sir Charles Barry be refused admission to that fraternity figured in the immortal school of Athens by the immortal Raffaelle? Most assuredly not. There, as in the sanctuary of the illustrrious dead in which his remains will be deposited a place may be clearly retained for him; and whenever Wren and Jones, Vignola, Peruzzi, Palladio, Sansovino, San Michele, and others whose title is undisputed, join that group in which Bramante and Archimedes are all conspicuous, Barry and Visconti, Schinkel, and Von Klenze (when he shall be taken from us), may find their places as no unworthy representatives of the architectural genius of the nineteenth century.

Tried by such tests, by the minutest study of his works, their number, excellence, importance, novelty, fitness, and promise of stability for ages, and by the influence exerted through his example upon the current practice of his art, Sir Charles Barry may by no hyperbolic straining be classed with Wren and Jones, with Wykeham and with Waynflete. Let us now trace, far too briefly, the steps of conscientious labour by which this glorious and enduring pre-eminence was attained.

Charles Barry was born on the 23rd of May, 1795, of parents in a comfortable position in life, and resident in Bridge-street, Westminster. From mere boyhood he displayed and indulged a marked talent for drawing; and I have been told that it was his habit to sketch all over the walls of the bedroom in which he slept. When no more space was left he would paste paper over the surface he had covered with scribblings of his fancies, and start afresh upon a new series. The first part of his education Barry received at Mr. Wright's academy, now Mr. Beaufoy's,—Carron House, South Lambeth, where he was at school as early as 1804; the latter part he gained at Christ's Hospital. At the age of sixteen he was articled to Messrs. Middleton and Bailey, respectable surveyors to the parish of Lambeth, with whom he appears to have remained about five years. One of these gentlemen, at least, must have been able to give his pupil artistic instruction, for I observe the name of Mr. Bailey, of Lambeth, appended to several designs in the exhibition of an ambitious character, such as "For a national museum and cemetery," &c., during the term for which his apprentice had been bound to him.

Barry must have been a tolerable draughtsman at the time of his entry into his master's office, for so early as 1812, before he was seventeen years old, he was admitted as an exhibitor at the Royal Academy; and singularly enough his first exhibited drawing was "A view of the interior of Westminster Hall," the very building which as it were served as the key-note to his greatest work in after years. It appears in the catalogue of 1812 as the production of "C. Barry, at Messrs. Middleton and Bailey's, Lambeth." In 1813 he made his *début* at the Royal Academy with an original design "for a church." In the following year his contribution is a design for "A museum and library, with an observatory." In 1815 he re-appears, still giving his address "at Messrs. Bailey and Middleton's, Lambeth," with a more practical effort, in the shape of "A design for a group of buildings for a nobleman's park; comprising a picture-gallery, library, music-room, conservatory, and billiard-room."

In April 1817 he quitted England in the company of a Mr. Conduitt, with whom he travelled for some time: his friend Wolfe subsequently joined him, and for some months they worked hard in Northern Italy, drawing and measuring, at Florence and elsewhere, with the utmost zeal and perseverance. At Rome he met Mr. Eastlake, and with him, Mr. Kinnaird (the editor of Stuart's 'Athens'), and Mr. Johnson (subsequently Prof. Johnson, of Haileybury College), he visited Greece in 1818, and made many beautiful drawings. One of these "A view of the west front of the Parthenon, taken on the spot," he sent to Somerset-house in 1821. Another, "A view of the temple of Theseus, at Athens, drawn and tinted on the spot in the year 1818," appeared in the exhibition of 1823. He returned to Rome with his port-

* From a paper read at the Royal Institute of British Architects.

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folios full, but with his pockets so empty, that, despite his earnest desire to go further a-field, he was on the very point of starting homewards, when he happily made the acquaintance of a gentleman of fortune, a Mr. Baillie, who was so pleased with his sketches, that he made him an offer of an engagement as travelling artist. With that gentleman, in 1818-19, young Barry went up the Nile several times, and visited the Holy Land, making beautiful sketches, from some of which engravings were subsequently executed for Finden's landscape illustrations of the Bible. He remained with Mr. Baillie for about a year and a half, and returned to England in July 1820. During the whole of his wanderings he kept an admirable journal, which it is to be hoped may be some day given to the world.

In that same year, 1820, he established himself in business at 39, Ely-place, London. I am unable to trace his first architectural employment, and can identify nothing earlier than the Manchester church, which he appears to have been employed to design in 1822. In 1823 he competed for in public competition, and obtained employment as architect to, the new church of St. Peter, at Brighton. In many respects this church was superior to any contemporary ecclesiastical work, and its popularity greatly enhanced that of its designer. Soon after this time Barry appears to have been a good deal employed at Brighton, in laying out the Queen's-park, building a house for a Mr. Attree; and another (Clarence-mansion, since much altered, but not by him) of a good Italian character, looking over the sea, has been pointed out to me on the spot as one of his early works: he also built the Sussex County Hospital. The Royal Institution, Manchester, and a house for Sir Thomas Potter, at Buile-hill, near that city, were built by him in that Anglo-Grecian style which Sir R. Smirke had mainly popularised; from which, despite fashion, Barry took the earliest possible opportunity of emancipating himself. His success—for such it assuredly was at the date of its execution—with the Brighton church led to his engagement to design a group of churches proposed to be executed by the Church Commissioners in the parish of Islington. The three carried out by Barry were respectively, St. John's, Holloway, Perpendicular, with a tower, to hold 1782 persons, at a cost of £11,809; Ballspond, a very similar building, to hold 1793 persons, at a cost of £10,947; and Trinity Church, Cloudesley-square, a larger but corresponding structure, to hold 2009 persons, at a cost of £11,535: the latter was completed about 1826. At a subsequent date Barry built the church of St. Peter, River-lane, Islington: this building, which cost only £3407. 2*s*. 7*d*., in the days of the cheapest and worst churches, was consecrated in 1835. To the best of my belief, he was only engaged upon three other churches during his career,—the parish church of Stoke Newington, which he almost entirely rebuilt and refitted; one at Hurstpierpoint, in Sussex; and another, St. Peter's, on Saffron-hill, Holborn, to contain 1783 persons, with a turret and vaults, at a cost of £9004. All of these, with the exception of Hurstpierpoint which is Middle Pointed, were, I believe, in the Perpendicular style, and were rather above than below the average work of the best men of the day who were beginning to make Gothic a somewhat special and exclusive study. His Unitarian Chapel at Manchester, the design for which he exhibited in 1840, at which date it was completed, was his only attempt in the First Pointed style, and attracted considerable notice at the date of its execution. Soon after his establishment in business, Barry obtained the appointment of architect to Dulwich College, and was soon employed to erect a new wing to that building; he also became connected about the same time with the construction of a new wing to St. Thomas's Hospital.

In 1827, Barry's increasing business and connection justified his removal westward, and we accordingly find him leaving Ely-place, for Foley-place. Among the most important of the studies made in that year was a design, which was approved of by Lord Gwydir, for the rebuilding of Drummond Castle, Perthshire, two views of which were exhibited in 1828. In 1829 he designed, but did not carry out, various additions to the Pitt Press at Cambridge; and struck at last upon the golden vein which ultimately made him a prosperous man. In the designs for the Travellers' Club, which were submitted in limited competition, Barry first revealed his resources in planning, and that refined perception of just proportion, both in detail and general distribution, in which he has scarcely ever been rivalled. The garden front is, so far as my knowledge extends, an absolutely original conception; and as such may, I consider, take its place in the history of art. The Pall-mall front has been frequently characterised by superficial observers as a copy or reproduction, with slight modifications, from Raffaelle's Pandolfini Palace at Florence. One moment's comparison of the two elevations will suffice to entirely dispel the idea. The Pandolfini Palace has only in common with the Travellers' Club-house, the accidents of being two-storied, having rusticated angles, and a doorway at the extreme right-hand side of the ground-floor. In every other respects the dissimilarities are most striking; the proportions of the windows are about one-third narrower in the Travellers' than they are in the Pandolfini: in the former, they are Ionic on the first-floor, and Doric on the ground; while in the latter, they are Corinthian on the first-floor, and have simply returned architraves and no order on the ground-floor. The four windows of the first-floor of the Florentine façade are surmounted with alternately angular and segmental pediments, and united by panels in the interspaces and horizontal members, while the five of the Pall-mall building are precisely uniform, and the wall is entirely free from panelling, and the running through of any of the members forming or decorating the fenestration above the cill level. One of the leading features of the Pandolfini is its deep plain frieze, adorned only with a very simple classic-looking inscription; while in the entablature of the Travellers' Club the frieze is reduced to so small a proportion, and is so highly carved, as in fact to do duty rather as an enriched member of the cornice than as a distinctive frieze at all. As a corroboration of the remarks I have ventured to make in respect to the universality of genius, and the immediate effect upon the public of any salient manifestation of it in the shape of a work of art, it may be noted, that from the date of its completion in the year 1832, to the present time, no architectural Zoilus has ever raised his puny voice to the disparagement of this real gem. The contract was taken early in 1830, by Messrs. Lees, at £19,000; and the total cost was £23,160. On the completion of this beautiful structure its architect was elected a life member of the club: a compliment, considering the very exclusive nature of its constitution, of no slight social and professional importance to a rising artist.

Pall-mall also possesses two ordinary house façades of great cleverness, executed by Barry, and the Imperial Insurance Offices, opposite to his great club-houses, and of about the same date as the Travellers'. While the last named was in progress, he was subjected to three disappointments, one of which annoyed him a good deal. He became an unsuccessful competitor for the Westminster Hospital, carried out by Inwood; for the Law Institution, carried out by Vulliamy; and for the Birmingham Town-hall, entrusted, as is well known, to Messrs. Hansom and Welsh, under very peculiar circumstances. In response to the advertisement issued at the close of 1830, calling for designs for the last-named building, Barry forwarded a noble scheme for a Doric temple of grandeur, and at the same time of so much simplicity, that his friends confidently averred that it might be well carried out for the £18,000 which formed the limit fixed by the committee. Barry's plan was so long placed in the ascendant, that he confidently reckoned on being employed to execute it. From first, however, it somehow sank down to third, and a design was at last adopted which, after utterly ruining the contractors, cost the corporation nearly double the amount to which they at first limited the outlay. Barry exhibited his design, which was much admired, in 1832. From that year his occupation appears to have been so incessant as to preclude his contributing to the Royal Academy, and it is not until 1840 that he re-appears in the architectural room. Nothing daunted by his bad luck with the Town-hall, Barry sent in designs (for the preparation of which two months only had been allowed) on the 1st November, 1832, for the Free Grammar School, commonly known as King Edward's, at Birmingham, which he won easily. This popular building, with its seven regular bays, and bay windows breaking through two stories at each end, was most carefully carried out in every detail, and in a good collegiate style, in that most beautiful building stone Darley Dale, and gave great satisfaction. It was completed in 1837, at a cost of £39,263. The study bestowed by Barry upon the working out of this building, and consequently upon the Tudor style generally, he found of the greatest possible service to him when subsequently called upon for the Houses of Parliament competition. It was about the period of the completion of the Birmingham Schools that Barry became acquainted with Welby Pugin, whose talents he always greatly admired. Pugin was selected and employed to work out the drawings from Barry's sketches for some of the ornamental details, and for the furniture

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of that building, and thus the foundation of their mutual regard and respect for one another's powers was laid.

The year 1834 was an eventful one for our profession, and especially for that member of it whose career I am now endeavouring to trace, since on the 16th of October in it took place that memorable fire which rendered the reconstruction of our national assembly house a positive necessity. That event occurred at a time when Barry was closely occupied upon several works of importance in addition to those already mentioned, such as various constructions at Bowood, for Lord Landsdowne, the Campanile Lodge and Golden Gates being in progress so late as 1838; the portico, and enlargement of the College of Surgeons, which was sufficiently advanced to show the general character of its design in 1835, and was finished in 1837; Lord Tankerville's beautiful Italian villa at Walton-on-Thames; and various alterations at Woburn for the Duke of Bedford. He had also been called in by the Marquis and Marchioness of Stafford, who had been first impressed with his talent for picturesque gardening by the terraces and other features which they had remarked at a *fête* give in the Queen's Park, Brighton. The architect was introduced to these leaders of taste at the time by Mr. Attree, for whom he had laid out the grounds in which the *fête* was given, and was subsequently employed at first in trifles such as vases flower-pots, and ornamental details; but ultimately in vast works at Trentham, Stafford House, and Cliefden so late as 1853; as well as in great designs for Dunrobin Castle.

In 1833, the extensive designs for the conversion of Trentham, an ugly house in a flat and uncongenial soil, into what that princely seat now is, were made. No one could be a better judge than the late Mr. Loudon of the local difficulties presenting themselves to the architect and landscape gardener. Mr. Loudon thus writes in May 1834:

"Trentham Hall, the residence of the Duke of Sutherland, is about to undergo extensive improvements. When we first heard of this, and that Mr. Barry was employed, we could not help doubting whether even Mr. Barry could make anything of this great dull, flat place, with its immense mansion, as tame and spiritless as the ground on which it stands. We have seen the plans however, and must confess that we were delighted and astonished with them beyond measure. Let no one henceforth ever despair of a dead flat. The modifications of the ground and the large lake and its islands, proposed by Mr. Barry, prove him to have as just a taste in landscape gardening, as he has a refined and correct one in architecture. The architectural flower-garden, which will contain several acres, will be the largest and best of the kind in England."

Barry's employment at Trentham Hall extended over about ten years. In 1836, he had also in hand the Manchester Athenæum, a well worked out but simple Italian building, costing about £15,000.

We now approach the great event in Barry's life,—the competition for the New Houses of Parliament. On October 16, 1834, the conflagration took place, and shortly afterwards Sir Robert Smirke was employed by the Department of Works to make plans, &c. for the rebuilding. Sir Robert Peel, always a kind patron to Sir Robert Smirke, appointed a committee to examine his designs. The committee publicly acknowledged themselves unable to form a sufficiently accurate judgment upon the merits of any plan, but recommended open competition and the appointment of a royal commission, which was accordingly applied for. To this course, so far as the appointment of a commission of five is concerned, they were no doubt mainly instigated by Sir Edward Cust's celebrated letter to Sir Robert Peel, dated Jan. 31, 1835. Sir Edward was however averse to the principle of competition in the matter,—he would have intrusted the selection of the architect to the commission he suggested. The style of the proposed building was determined by parliament should be either Gothic or Elizabethan.

On July 17, 1835, the country obtained from the king the issue of a royal commission to fix the site and obtain designs for new Houses of Parliament. The terms of the royal commission provided for a selection of not less than three nor more than five designs, all of which were to be reported to parliament, and one of the three or five definitively recommended for adoption. The acting commissioners were, the late Mr. Hanbury Tracy (afterwards Lord Sudeley), Sir Edward Cust, Thomas Liddell, Esq., and George Vivian, Esq.; Lord Duncannon being at the time First Commissioner of his Majesty's Woods and Works. Ninety-seven designs, comprising upwards of 1000 drawings, were contributed in competition for three or five premiums of £500 each; and after a private view for the members of both Houses of Parliament, &c., and the confirmation by a parliamentary committee of the report of the royal commissioners, were publicly exhibited from the 28th of April. The royal commissioners state in that document, approved by his Majesty, and presented to both Houses of Parliament on the 29th of February, 1836, that "although a difference of opinion may exist between us with respect to the ground-plans separately considered, we are all unanimous in our opinion that the one delivered to us marked 64, with the emblem of a portcullis, bears throughout such evident marks of genius and superiority of talent, as fully to entitle it to the preference we have given it in our classification; and we have no hesitation in giving it as our opinion that the elevations are of an order so superior, and display so much taste and knowledge of Gothic architecture, as to leave no doubt whatever in our minds of the author's ability to carry into effect your Majesty's command." The design thus recommended proved to be the one drawn, to a great extent, by the very hands of the late Sir Charles. It is not generally known, but it is nevertheless the case, that Barry entertained a predilection in favour of an Italian style for the Houses of Parliament, and went so far, in spite of the formal prescription, as to prepare sketches and studies, some of which are still in existence. The second premium was awarded to Mr. Buckler, the third to Mr. Hamilton, and a fourth to Mr. Railton. It was not from these rivals, however, that the most strenuous efforts subsequently made to wrest away the precious prize from the victor emanated. The battle of the styles appears to have been opened by the late Mr. W. R. Hamilton's first letter to the Earl of Elgin (July 1836), recommending Greek, and its disciples, Sir Robert Smirke and Mr. Wilkins. Mr. Hamilton's letter was followed by a second in the same year, in February 1837, and an article on Barry's designs in the "London and Westminster Review." These were replied to ably by Colonel J. R. Jackson, who supported Gothic on the plea mainly of nationality. Mr. Hamilton's were endorsed by Mr. Wilkins (under the pseudonym "Phil-Archimedes"), Mr Grellier, and Mr. A. W. Hakewill; and Colonel Jackson's were anticipated by Welby Pugin and Benjamin Ferrey, who, with T. L. Donaldson, stood up honourably in favour of the execution in its integrity of the selected design, with none of the petty jealousies displayed by Savage, Hopper, Cottingham, Wilkins, and others. Acrimonious pamphlets, in the shape of "observations, apologies, scrictures," &c. were freely bandied about. Accusations of favouritism were made against Sir Edward Cust, on the plea of his having been concerned in assisting in the production, a year or two previous to the competition, of a curious little etching by Barry, now very rare, showing the defects of the lowness of Wilkins's designs for the National Gallery, and the effects of a loftier structure. That somewhat satirical performance had offended Wilkins, who had previously come off victorious in a competition for the works at King's College, for which Barry had sent in; and its execution may account for the sharp stings of Wilkins's very pointed pen.

It is curious, in looking over these old controversial wranglings between Goth and Greek, to note how little we have changed. The battle, unfortunately, still wages amongst us at the present moment; and we are obliged to confess that the spitefulness of yesterday, and of many a yesterday, is but a version, with scarcely a variation, of the spitefulness of to-day.

All these hot agitations and heartburnings, coupled with the proverbially feeble administration of the Department of Works, and the slow and desultory action of Parliamentary committees, retarded, even more than the physical difficulties to be overcome, the commencement of the works. Cotemporary protests against all this *friction* were by no means wanting, and the following, from the pen of Mr. Bartholomew, is among the most animated, and evinces a just appreciation of the powers of the architect, and the difficulties which lay in his path:—"The nation may take this pleasing assurance," he observes, "that, confided to Mr. Barry, a senate-house worthy of the empire will be produced, with every detail correct, not only in the principal parts of the pile, but also in the most retired parts of it. This excellent architect is rarely found straying from his subject; he studied it like a Freemason of the olden time: the nation should, therefore, second liberally his generous efforts; it would afterwards be very proud of them: it should allow him to *build indeed* substantially with granite, with Portland stone, and with oak; it should deny him no proper ornaments; they cost comparatively little, and if denied now, regret will be felt hereafter."

In the interval which elapsed between the acceptance of his

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plan and the laying of the first stone, which took place on the 27th of April, 1840, Barry was, as we shall now see, by no means idle. In addition to the preparation of the vast quantity of designs and working drawings necessary for entering into contracts for the Houses of Parliament, and for carrying on the works he had in hand before the competition, he proceeded in 1837 to enter actively into the limited competition for the Reform Club, to which Messrs. Basevi, Blore, Smirke, Burton, Cockerell, and he himself, had been invited. On December 13, in that year, the committee proceeded almost unanimously to fix upon his design, which was ultimately carried out at a cost of about £80,000. This noble building is so completely patent to every Londoner, and its merits are so universally acknowledged, that I shall offer remarks upon three points only in connection with it. First, then, let me remind you of the entire originality of converting the usual cortile of the Italian palace into an internal and most beautiful hall. Secondly, let me call your attention to the perfection of the domestic arrangements, which teaches us that the most minute attention to comfort, and the satisfactory working of utilitarian necessities are quite compatible with the exercise of the most delicate sense of refinement and the hardihood of bold and towering genius. Thirdly, I would beg to vindicate the memory of Sir Charles Barry from a charge of plagiarism, to the full as absurd as that which has been grounded upon the fancied resemblance of the Pall-mall front of the Travellers' clubhouse to the Strada Pandolfini front of Raffaelle's Florentine palace. It has been alleged that the Reform Club in some degree finds its prototype in the Palazzo Farnese. Setting aside the utter nonconformity of any two features in their respective plans, let us for an instant compare their elevations: the one contains thirteen bays in width, the other nine; both are three-story buildings, with large crowning cornices, and there the resemblance ends. Every detail is absolutely different; and let me add, that I do not think Sir Charles Barry ever did or ever could copy: his whole system of working was opposed to anything of the kind. Should you ever have the opportunity of tracing out the progress of his thoughts, as I have frequently, and as no doubt all his pupils have, through any series of his studies for any particular building, you will find that the work is always as it were growing evenly under his hand, from the slightest generalization in the first small scale sketch to the plotted-out bay or repeat, and subsequently to the large scale detail; then back again into another general elevation, to see how far that particular detail will work well in combination, then altered according to the result of that test, and roughed out again to a large scale, to make sure of the effect of the parts when near the eye; and so on frequently until his fastidious judgment would get almost bewildered under the multiplying and conflicting impressions produced by the various studies. The man who works in that way perseveringly may at least make sure of two things,—that his work will be good; and that it will be his own and nobody else's.

Among the practical questions connected with the new Houses of Parliament, one of the most urgent was the selection of the stone; and as the mooting of that question led to the important survey by a commission in the year 1838, I may perhaps mention the immediate connection of Sir Charles with that movement. It appears from information with which I have been supplied by our kind friend Mr. C. H. Smith, the only surviving member of the commission, that, soon after the fire, M. Joubert, of Caen, sent specimens of Caen stone to about twenty different members of Parliament, and among others to Mr. Joseph Hume. Mr. Hume referred to Mr. Smith for a report, which was forwarded to the Department of Works, and by them to Mr. Barry, who at once wrote an admirable note to Mr. Hume, stating his views and his intention of making a tour throughout Great Britain to collect information. It was then arranged that scientific and practical men of eminence should go on the same errand with him; and the result was, that during fifty days in the autumn of 1838, the information was collected which has been embodied in the valuable report of the comissioners.

In 1840 Barry made fine designs, which were well carried out, for converting Highclere, a seat of Lord Carnarvon's, into an irregular version of Italian. About the same time he completed additions to University College, Oxford, and I believe made comprehensive designs for buildings at Worcester College, in the same city. In the year following the laying of the first stone of the Houses, Barry began to reap the honours he had so fairly won,— being elected Associate that spring; Associate elect in 1842, and Royal Academician in Wilkie's place in 1844. His first recognition from abroad dates from Rome Dec. 29, 1842, conveying his affiliation to the Academy of St Luke's: his second from St. Petersburgh, Dec. 31, 1845. His election into the Russian Royal Academy, which was accompanied by the presentation of a diamond snuff-box from the Czar, was ultimately followed by his nomination to those of Belgium, 9th Jan. 1847; Prussia, 28th April. 1849; Sweden, 25th May, 1850; Denmark, Antwerp, and the American Institute. In 1855 he received the gold medal of honour for architecture, given at the Exposition Universelle of Paris, of which he acted as juror.

In 1841 Barry produced his noble design for Bridgewater House, for Lord Ellesmere, which was very different from that which he commenced as late as July 1847. Probably no building he ever executed was more elaborately studied, and the result is shown in much of the beautiful detail which decorates that princely structure.

The first stone of the superstructure of the Houses of Parliament, the angle of the plinth of the Speaker's house nearest the bridge, was laid (as has been already stated) on the 27th of April, 1840, by the architect's wife, without any public ceremony, and in the presence of a few personal friends only. The first stone of the Victoria Tower was also laid in the same unpretentious way by Lady, then Mrs. Barry, on her own birthday, the 22nd of December, 1843.

From 1840 to 1843, the works at Westminster, to which neighbourhood (32, Great George-street) Barry had removed in 1841, proceeded at a splendid pace; but shortly after that date difficulties arose against which even his strength, industry, energy, and unrivalled dexterity in managing recalcitrant employers, failed to make successful head. The only wonder is that he was not killed by incessant worries and annoyances. To these cares his son Edward alluded in the following terms, in the paper he read here on the 1st February, 1858, on his father's great work:—

"In the session of 1844, a committee of the House of Lords, which was appointed to inquire into the progress made with the works—in consequence of a natural desire on the part of their lordships to enter their new house, and a still more natural inclination to blame an architect for anything inconvenient—commenced its labours, and reported that several alterations had been introduced into the design by the architect, without any authority from the government; an accusation he explicitly denied, by stating that he had received authority, express or implied, for all he had done. The alterations alluded to were a re-arrangement of a portion of the plan between the Victoria Tower and the House of Lords.

Great objections were made by some members of the Lords' committee to these modifications, and many inconveniences foretold, both to her Majesty and their lordships; but I am not aware that practice has justified these predictions, or reversed the opinion of the committee of the House of Commons, which sat soon afterwards, and resolved 'that no blame was to be attached to Mr. Barry for the course he had taken, and that they had every reason to believe that all the alterations hitherto made had conduced to the convenience and general effect of the building.'

It was at this time that many complaints began to be made in parliament about the so-called delay in completing the building; and the anxieties consequent on the various committees and other inquiries, in addition to the unavoidable responsibilities of the architect, caused him a serious illness, and thus made a reality of that delay which up to this time had been imaginary, as far as he was concerned.

Indeed, had it not been for the hearty and generous support of Lord Lincoln (now Duke of Newcastle), who was then First Commissioner of Woods, I do not think the works could have been carried to a completion by my father. His lordship took special pains to make himself personally acquainted with the nature and bearing of the various complaints, and, having satisfied himself that they were not based on justice, threw the whole of his official weight into the scale, and gave the architect no half-hearted or stinted support in carrying out his views until the close of his official connection with him."

All honour to the Duke for this manly, kind, and persistent support of a great man, worried almost to death; and equal shame to those who hounded on the senseless cry from which this official shield in part protected him. I need scarcely remind this assembly of the feelings with which Barry was regarded by our late esteemed president, the Earl de Grey. On the occasion of the presentation to Barry of the Queen's gold medal in these rooms, on the evening of June 3, 1850, Lord de Grey touched on the peculiar trials to which the architect of the New Palace at Westminster, as it then began to be called, had been exposed with his usual light but most skilful hand, in the following terms:—

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" . . . May you live to see the magnificent work now in your hands completed. St. Paul's was thirty-four years in its erection: you have not occupied half that time as yet, and have made a progress which, if it had depended on yourself, would have brought the Houses of Parliament nearly to completion; but the means of working have not been at your disposal. Sir Christopher Wren was intrusted with a large and striking work, destined for a single purpose: it was to be a great and glorious temple, dedicated to the worship of the Most High;—but your work is to be devoted to I know not how many purposes. Sir Christopher Wren had to deal with men who knew what they wanted; and, no doubt, he received his instructions from men who knew the purpose to which the building was to be dedicated, and [to a certain extent] what was required to carry it out;—but I am sorry to say that that is not always the case with respect to the buildings intrusted to you. Sir Christopher Wren's masters [however tyrannical and annoying] were few;—yours are legion. I am sorry to say, that august assembly which has most to do with the erection of this magnificent structure has in it a vast number of men who ask questions, make suggestions, and offer criticisms, while at the same time they do not know what is wanted, or, indeed, what they want themselves. It is not wonderful then that the architect should be impeded, and that fault should be found without any good or substantial ground; and yet, with all these hindrances and drawbacks, you have made a progress in the stupendous work which you have undertaken which is perfectly surprising."

Of the true nature of the labours by which alone the difficulties of his task and position could be overcome, or even coped with, Sir Charles Barry has given the simplest, the most manly, and I verily believe the truest possible picture, in the following words, extracted from an official letter and protest of his, which must for ever live as an indelible stigma upon those for whom the artist's noblest work was done:—

"I may here add, as a ground for the increase rather than reduction of the customary remuneration in respect of public works, that owing to the troubles, delays, and perplexities attendant upon official communications and requirements, the architect's labours and anxieties are much greater than those which he has to incur in private practice; and if this be true of public buildings of an ordinary character, it may be easily conceived that those labours and anxieties have been incomparably greater in carrying into effect such a work as the New Palace at Westminster, in which not only the government, but committees in parliament, and even the public, have unceasingly assumed the right of criticism and control. As one proof among many others that might be adduced of the enormous amount of labour that has already devolved upon me in conducting this national work to its present state, it will not be irrelevant to mention that no less than between 8000 and 9000 original drawings and models have been prepared for it, a large portion of which have emanated from my own hand, and the whole of the remainder have been made under my own immediate direction and supervision.

I consider that I am entitled to a further remuneration for special services not connected with my professional duties in respect of the works of the building. These services consist of attendances upon the Fine Arts Commission, reports and numerous drawings prepared in compliance with the orders of that commission, frequent communications with its secretary and with the artists appointed for the decoration of the interior of the New Palace; attendances upon committees of parliament in every session from the year 1841 to the present time, preparing data required by those committees; giving and correcting evidence, making up voluminous returns, in compliance with the orders of the House of Commons, one of which occupied myself and clerks for nearly four months; attendances to give evidence upon two commissions of inquiry with reference to Dr. Reid's system of warming and ventilating, preparing plans and other documents for the use of those commissions; conferences and communications with the law officers of the crown with reference to contracts, disputed claims, and threatened legal proceedings; numerous reports and estimates required from time to time by the Office of Woods, negotiations and arrangements consequent upon establishment of government workshops at Thames-bank, and the superintendance of the collection of above 3000 casts of the best specimens of mediæval art to be found in this as well as in foreign countries for the use of the wood carvers; preparing plans, estimates, &c. for providing accommodation for the whole of the public records of the kingdom; and other miscellaneous services."

Before such a crushing list of altogether unrequited exertions, how sadly the official sophisms of "my lords" betray the thinness of the stately mantle through which peep out what closely resembles costive penury and meanness. Against their behaviour and conclusions in respect to the remuneration of Sir Charles (a subject upon which I scarcely dare trust myself to speak), it must ever be a satisfaction to the members of this body to recollect that its council protested respectfully, but with firmness, and with a full appreciation of the special pleading of the representative for the time being of her Majesty's Treasury, in the following terms:—"Resolved,—That 5 per cent. upon outlay has been and is the only rate of charge recognised by the profession as fairly remunerative in the average practice of architects. That it is to be deeply regretted that it should be proposed to depart from the above rate in the instance of the New Palace at Westminster,—a building involving in its design and execution the exercise of the highest professional attainments. That the example which would be set by her Majesty's government should the course proposed be carried into execution (a legal appeal against their decision being practically impossible) is to be regarded as disastrous to the future prospects of architecture in this country, as calculated to lower the character of public monuments in England, and unworthy the goverment of a great nation, whose obvious duty it is adequately to foster and protect the genius of its artists."

Under such complicated annoyances Barry's health must inevitably have broken down altogether if it had not been for the support, comfort, and affection he received in the bosom of his family and the circle of his own friends. Happily for him, in his domestic relations no man could be more auspiciously situated; and he has in moments of confidence expressed to me his sincere and almost solemn thankfulness for the manner in which all about him repaid the love he lavished unstintingly upon them.

In the year 1840 his eldest son Charles entered his father's office, therein to acquire that professional knowledge which such a school could so well give, and became the friend and associate of Mr. Banks, his present partner, then the chief confidential assistant of Sir Charles. Together they were actively concerned in all those varied works which for the next eight years were engrossing Sir Charles's attention, including the commencement of the New Palace at Westminster, and its prosecution till the year 1848, in which, with the advice and sanction of Sir Charles, they entered into that professional connection founded on intimate friendship which still continues Sir Charles's kind and valuable advice—at all times freely given to any young members of the profession—was specially afforded to Messrs. Banks and Barry, and greatly prized by them. From this time for the next two or three years the partners occasionally assisted, and at times represented, Sir Charles professionally, until their own practise increased so much as to require their whole attention; and the younger son, Edward Middleton, who had been articled by his father to Messrs. Wyatt and Brandon, and who on the dissolution of partnership between my brother and Mr. Brandon about a year after Mr. Edward Barry had entered their office, served the remainder of his term with the former, had become able to assume that place of confidential assistant and representative which he held till the day of the decease of Sir Charles, who has bequeathed the drawings, papers, and books relative to the New Palace at Westminster to the younger son, as having then for many years past been specially connected with his father in carrying out that great work.

Of the Houses of Parliament it is scarcely necessary to speak further. You know their merits,—you as architects, familiar with all that is greatest and most impressive in our art, know as well as I know, that they will live to speak for themselves for centuries after the memory of such unmannerly detractors as Mr. Denison shall have passed away, and that as long as they shall endure they will tell but one tale.

No public building in Europe possesses a more ingenious and effective plan, a more perfect homogeneity of parts and style, a more graceful outline under every point of view, and greater technical excellence and beauty. Let the most critical observer wander into every nook and corner of that enormous structure, and endeavour to detect a neglected point where the failing attention or ability of the architect have allowed a degeneration into meanness of finish, dissymmetry of axes or leading features, faulty proportion of line or detail, or anything like what is commonly called "a bungle;" and if he finds one it will certainly be more than I with very close attention have ever been able to do. Supposing however that he may succeed, where I and many others have failed, let him, full of the motes he may have found in his brother's eye, take his stand either on Waterloo or Hungerford bridge, or on the river side near Lambeth Palace, and from one of those points on a fine afternoon watch till the sun goes down; and if he does not lose the impression of the "motes" in the enjoyment of one of the most exquisite pictures ever architect provided to feast a painter's eye, he "hath no music in his soul."

As practical architects we are especially bound to recognise the extraordinary technical resources called into play in the structure and fitting up of the Houses of Parliament. At Barry's

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call, and under the vivifying influence of his daring and intelligence, a new race of workmen seemed to spring into existence. Trained by Pugin, and led on by John Thomas, workmen grew into artists; and who shall say for how much of the admirable masonry and carving which are now so rife throughout our land we are not indebted to the judicious establishment of the school, and prototype of our present Architectural Museum, at Thames-bank, by and under the auspices of Sir Charles Barry? Ever appreciative of the technical skill of others, he enlisted all the energies of those manufacturers and masters who first woke up to the real capabilities of industrial art. For him, Hardman, Crace, and Minton exerted all their energies; giving him at once novelty, beauty, and excellence. Products and decorations which are now common enough were, when Barry and Pugin first employed them, rarities attainable only after repeated experiments, and with extreme difficulty. Mechanical arrangements for saving labour, the capacious mind of the former at once appreciated and applied, and, but for his great power in that respect the Houses of Parliament could never have been completed, as they have approximatively been, up to the present hour. It was given to him at once to know how and when to use men as tools, and tools as men,—never confounding their legitimate functions, but deriving every possible aid from each and all. We cannot forget the ingenuity of all those contrivances for scaffolding and hoisting which were so ably described to us by Sir Charles's eldest son, on the 15th of June, 1857; neither can we overlook the debt we owe to one who, in all these matters, has so clearly shown us what may be done by intelligence and energy in overcoming every possible variety of mechanical and material obstruction an architect is likely to meet with in the course of the most diversified practice.

Nothing tended more to retard a general appreciation of the architectural merits of the Houses of Parliament than the necessarily slow and protracted realisation of its chief vertical features and sky-line. The grand horizontal continuity of the river front, admirably calculated to contrast with and enhance the aspiring loftiness of the Clock and Victoria Towers, appeared comparatively unreasonable and monotonous, until those features were brought to proximate completion. But a few years will, I sincerely believe, witness an entire revulsion of feeling with respect to the popular estimation of this building; and those who will then have grown accustomed to it in its entirety, and who may have learned to apprehend the skill with which its plan has been adapted to correspond effectively with the most complicated, and apparently antagonistic, exigencies, will wonder at the growls and grumbles which have continually proceeded from those who have persisted in pronouncing sentence on their own prognostics, rather than on the real schemes and designs of their truly accomplished architect, which they would not trouble themselves to apprehend.

In addition to the works I have already alluded to many more might be enumerated, several of which in a less note-worthy career would be regarded as of very great importance. Such, for instance, are the Privy Council Office and Trafalgar-square alterations; the terraces and additions to Shrubland (1849-54), for Sir William Middleton, done about 1849; Gawthorpe, a Gothic mansion, in Lancashire, (1850-52), for Sir Kaye Shuttleworth; Kiddington, Canford Manor, Dorsetshire (1854-5), for Sir Josiah Guest; Schools, &c., at Dowlais (1855), for the same client; additions to the residence of Sir Isaac Lyon Goldsmid, in the Regent's-park; Harewood (1854-5), a large addition in a sort of Roman style, to his seat near Leeds, for Lord Harewood; Duncombe Park, for Lord Feversham; a Tudor house for Mr. Currie, near Leatherhead; Ensham Hall, for Lord Macclesfield; Cobham, for Sir John Cam Hobhouse; and Kington Lacey, for Mr. Bankes. The last-named an early work, the rest with scarcely an exception since 1840. Among his designs either not strictly or not at all carried out, may be mentioned his projects for New Westminster-bridge; for Law Courts on the site of Lincoln's-inn-fields (made in 1838), and on a site abutting on the Strand by St. Clement's (made in 1852); for the reconstruction to a great extent of Northumberland House; of Drumlanrig Castle, for the Duke of Buccleuch; and of Buchanan House, for the Duke of Montrose; and for the completion of the Horse Guards, towards the Parade.

In 1849 Barry was appointed a Royal Commissioner for the Exhibition of Industry of 1851, and as a member of the Building Committee (on which he sat with Robert Stephenson, Brunel, the Duke of Buccleuch, Lord Ellesmere, Sir William Cubitt, our President, and Professor Donaldson), he took a most active part in the early settlement of all matters relating to the building. The section of the columns, with its ingenious provisions for the attachment of girders and superposition of other columns, the general proportions and arrangement of many of the leading parts, and the form of the transept roof, which I saw him sketch on the suggestion of Brunel, that rather than cut down or exclude trees it would be better to roof them in, were all his; and but for his having been beaten on the score of time and expense in the view he took of the desirability of covering the nave also with a semi-cylindrical roof, as has been done at the Sydenham Crystal Palace, he would no doubt have continued to render greater practical assistance than he did till the opening of the Exhibition.

As a Royal Commissioner he dissented from the South Kensington Museum and National Gallery schemes, and forwarded to his Royal Highness, the President, for submission to his colleagues, a comprehensive and most able scheme for an extension of the British Museum upon the site of some of the streets and squares now immediately adjoining it. In how magnificent a manner he would have dealt with the National Gallery in its present commanding position, is well though slightly shown in many of his existing sketches, which, it is to be hoped, may be published in facsimile.

Mr. Barry became Sir Charles in 1852, having been knighted on the occasion of her Majesty's making, for the first time, in February of that year, her state entrance through the lower story of the Victoria Tower; and shortly afterwards he began to gradually withdraw from active practice. In 1853 he removed to Clapham. Among his last and finest designs were the series for great additions and alterations to Clumber, for the Duke of Newcastle in 1857; plans and sketches for the construction of a building for the Royal Academy of Arts, on the site of Burlington House; drawings for the Halifax Town Hall; and that design or rather collection of designs for the improvement of the western portion of London, which he contributed as a sort of rider to the designs of his son Edward for the Government Offices. This last I venture to consider one of the most important designs he ever made. I look upon it asa legacy to his country of almost corresponding grandeur of treatment with that bequeathed to us by Sir C. Wren and prepared after the fire of London. Could but the scheme conceived by the architect who has shown us in the towers of Westminster and in the general composition of the Houses of Parliament what he could supply materially for the embellishment of the metropolis be realised, there can be no doubt that London would be the most beautiful and majestic looking city the world has ever seen.

In conversations I have had at different times on the subject of architecture with Sir Charles, he has always insisted on the indispensability of symmetrical arrangement, on sustained tranquility of effect obtained through the reduplication of similar parts, on study and refinement in detail, and especially upon care in the grouping of masses, and the treatment of the sky-line in connection with landscape effects. It was his general practice, he has told he, to get out his roof plan as one of the earliest drawings in working out any design. The architects for whose works he professed the greatest respect were San Michele, Michael Angelo, Vignola, Peruzzi, Soufflot, Perault, Vanvitelli, Gibbs, Chambers, Jones and Wren. For the latter his admiration was unbounded, and it was one of the latest acts of his life to give what assistance he could to the embellishment of Sir Christopher's great masterpiece.

In the summer of 1858, at the suggestion of Mr. Cockerell, Sir Charles was invited to become a member of the committee for administering the St. Paul's Cathedral fund, raised for the purpose of assisting the dean and chapter in providing, firstly, for the special evening services, and afterwards for the decoration of the cathedral. He entered heartily into the proceedings of this committee, and scarcely missed a single meeting. The surveyor to the fabric is anxious to bear witness with gratitude, both to the value of his councils and the uniform kindness of his manner.

As it was sometimes necessary in the alterations that have been decided on, and already partially carried out, to take steps regarding which there could be no positive indications of Sir Christopher's mind (although fortunately, in the main, there are such indications), it was of the greatest value to have an adviser who was so capable of deciding what Sir Christopher Wren would have been likely to have done under the new circum-

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stances, and one who was independent of a superstitious veneration for the original arrangements, when their change became desirable in consequence of the alteration of other parts. One of the last letters written by Sir Charles Barry was on the subject of the works in the cathedral to the Dean of St. Paul's, by whom his premature loss is deeply regretted, as it is by all others connected with the cathedral or the committee.

On all possible occasions Sir Charles Barry urged the necessity for a system of more complete and profound architectural study than has yet been organised amongst us. Quietly, though I have reason to know most strenuously, his views on this head were pressed upon the attention of his colleagues in the Royal Academy, and it was his earnest desire that the professorship of that body should be elevated into real practical efficiency.

In the formation of the Architectural Publication Society, Barry gave valuable and willing aid; but from compliance with the request of the committee for assistance towards the illustrations he always excused himself, on the ground that his sketches were too slight to be placed before the public. When however the article "Baalbec," compiled for the 'Dictionary of Architecture,' issued by that society, was submitted to him, he acceded most willingly to the wishes of the committee, and prepared the description (afterwards printed) of the ruins at that place, from his own memoranda and sketches. This assistance was the more remarkable and gratifying, as it is probable that with the exception of a short but often referred to contribution to Gwilt's edition in 1825 of Sir William Chambers's 'Treatise on Architecture,' this account is the only literary production from his pen; in fact, he had quite sufficient employment for it in the many and able reports and descriptions he was daily called upon to make. His interest in the Architectural Publication Society he kept up to the last, having replied within a month before his decease to an inquiry made by the secretary as to the peculiarity of sound in a certain room in one of the buildings erected from his designs. It is also reported that he was engaged upon an account of the Architecture of the Holy Land, for the same work, at the date of his untimely demise.

I know not how any moral that the ablest rhetorician in the world could draw from Sir Charles Barry's professional career could be made to speak more strongly, or to admonish us more stringently, than the facts of his life, and the monuments he has left behind him, do for us unerringly, if we will but open our hearts to apprehend and study them aright. His incessant labours, first to learn and then to practise, again to learn and again to practise, and again, and again, and again to learn and practise, so long as his physical energies could support the activity of his intellect, should convey to us all a lesson of profound humility, and a stimulus to exertion of the most active kind.

If he with all his natural genius and aptitude for art could achieve success, in the measure in which he did achieve it, only by never-ending, ever re-beginning toil and study, how can we emulate even an approximation to his excellence in our art without an exercise of both increased in the ratio of the disparity between our own natural powers and his? His life is only another practical illustration of that which the lives of all the greatest artists who have ever lived—of Titian, of Michael Angelo, of Raffaelle, of Leonardo da Vinci, of Albert Durer—already bear witness to,—that study and practice must in art ever go on hand-in-hand. Study without practice will but make the pedant; practice without study can but multiply busy worthlessness. He who would ever be in our art what Sir Charles Barry was, must don the same armour, and fight for every step in the upward struggle with the same weapons, and with equal courage and pertinacity.

THE DECAY AND PRESERVATION OF BUILDING MATERIALS.*

By D. T. Ansted, M.A., F.R.S.

The subject of my present lecture is eminently practical, and hardly admits of much variety of illustration; but I am sure that none of you can have examined, or even glanced at the numerous specimens of architectural construction in the older and more picturesque cities of England and the Continent,—you cannot have admired the graceful tracery of Westminster Abbey,—you cannot even have looked at the rich detail of the noble building recently erected so near it, by one whose genius will, perhaps, be willingly acknowledged now that he has departed from amongst us,—without noticing the facts I am about to refer to. You will there see, at every turn, fresh proof of apparently capricious and unaccountable decay. You will find many old stones unaltered, while many new ones are mouldering fast into rottenness; and you will, I believe, be interested, in spite of the apparent dryness of the subject, in anything that will inform you about a result so painful, so irregular, and so desirable to check, if in any way its prevention is possible.

Our building materials are of several kinds. Let me point out to you the principal varieties—their peculiar uses—their relative value for special purposes—and the special causes of decay in each. I shall then endeavour to put before you the modes by which such materials may be, at least in some measure, preserved from decay.

There is one thing which I may say with regard to all building materials of the nature of stone,—namely, that wherever it is found forming part of the earth's crust as a mass of rock, it is invariably, if it comes to the surface at all, injured and altered near the surface. In a granite district, for example, where there is scarcely any soil lying over the granite it scarcely ever happens that the upper portion of the granite does not to a certain extent exhibit marks of alteration. In all the common absorbent stones which are ordinarily used for building purposes, this is much more remarkably the case. And, to a certain extent, the extent to which the stone would be injured may be estimated by its appearance where it has been thus exposed for a long time to the action of the atmosphere. But that can only be taken as a partial measure of the injury likely to occur, because in some cases it will happen that stone will stand exposure perfectly well in its own atmosphere, and when the surface only is exposed, without having been removed from the bed, although that same stone when it is removed from the bed, particularly when it is placed in a different position from that which it occupied in the bed, will decay much more rapidly. Still, as I have said, it is an indication, and you will generally find that in a granite district a surface of good granite is exceedingly hard close to the top, and a decomposing granite worn and rotten. In a sandstone district there will also be a certain amount of decomposition, dependent on the value of the stone. And in a limestone district there will generally be considerable decomposition; in fact, the whole of the upper bed of limestone will be converted into vegetable soil.

Let us now take the building materials in regular order. First of all there is the group of which granite is the representative. Granite consists of a number of crystals imbedded in a crystalline base. In other words, it is a mass of crystalline minerals crystallised altogether. That is the essential nature of granite, and the point in which it differs from most other stones. This explains at once its value, and the nature of its decay. Its value, because granite being composed entirely of crystallised matter is non-absorbent, and very little exposed to injury, there is no no opportunity for decomposing agencies to get to it, at least without the lapse of a very long period of time. But it is also necessary to observe that granite consists of various kinds of crystals, and some are more liable to decay than others. Among the crystals that form granite are crystals of quartz, a material so durable that one hardly expects it to fail at all. But quartz, under certain circumstances, is capable of assuming a state in which, by the action of the weather, it will decay. Thus, although granite, as a stone, seems scarcely liable to injury, yet all the different parts of it are really capable of decay. With regard to the prevention of granite from decay, I do not know that it has ever been attempted. The only thing to be done is to select the better kinds.

Now we come to the group of freestones. Freestones are either sandstones or limestones. The sandstones form a large group, but they are not very extensively used for the more decorative parts of buildings. They are at any rate little used in London, and there are many reasons for this. Sandstone consists for the most part of quartz sand, and I have told you that quartz forms a large part of granite. The particles of quartz are however cemented together by some foreign combining substance; sometimes this substance is apparently silica, and in that case the stone will be almost unchangeable. Such is the sandstone worked in Edinburgh, and obtained at Craigleith. It is a stone which scarcely injures by exposure. Most of the sandstones, however, are cemented together, either by carbonate of lime, which has been filtered in by the action of water, by a mixture of clay and carbonate of lime introduced in the same

* From a paper read at the Royal Institution.

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manner, or by the presence of oxide of iron. All these cementing media are of course liable to the action of foreign substances upon them, according to their nature. And if these give way it is clear that the stone itself must give way. The Yorkshire stones are the next in value after Craigleith, and are very good. Some of the dark-coloured Scotch stones are also excellent. All the sandstones used may be grouped in these three ways:—those that are very hard, very compact, very fine in grain, and, generally speaking, of a pale colour; those are durable, but costly. Then, there are those that are hard and laminated. That is the character which belongs to almost all rocks that have been found in water, but in some it shows itself more markedly than in others. In stones which are completely laminated, the appearance is like sheets of paper placed one over the other, and you can almost separate them. Those stones are easily perishable. There are, however, laminated stones, such as those I am now referring to, of good quality. These are generally not of very fine grain, although they may be so. They are most frequently of a mixed grain, made up of particles of sand and small pebbles of different sizes. Very often they have reddish tints of colour, owing to the presence of iron, and they are often very irregular in their character. There are also some soft stones which are laminated, and generally red, but soft and bad. These are the three kinds of stone.

They are subject to decay in this way:—First, from the lamination. Having been formed in water, they have been deposited in beds one over the other, and never become entirely free from water, and when exposed to the air are liable to give off the water by evaporation, and take it in again by absorption when rain comes, or when the atmosphere is damp. After this, if a change of temperature follows, and a severe cold sets in, the temperature of the stone passing below the point of the extreme density of water, the water begins to expand. That expansion before and whilst freezing is one of the properties of water with which you are probably acquainted. You all know that if you leave water in a jug with a narrow neck, and frost sets in, the water will expand, and break the jug. In the same way laminated and absorbent stones will break. The water gets in, but cannot get out freely. It expands, and the stone breaks. Then again, water entering in the manner I have described contains foreign substances floating in the atmosphere which are soluble in water. These substances include a large number of gases,—acid gases for the most part, but some others. For example, they include carbonic acid gas, and carbonic acid dissolves in water; they include also sulphurous acid, passing into sulphuric acid, and this is taken up by the water. They include also sulphate of ammonia; all these substances being produced in the atmosphere of large towns. These substances entering into the body of the stone, begin to act upon the cementing medium. If the cementing medium is easily acted on chemically by these substances, it is of course very soon removed. If it is not easily affected by them, then the stone remains unaltered; but, generally speaking, it is the case that sandstones that have either lime or clay as their cementing medium, are more or less affected by foreign substances entering into them through the atmosphere. There is then a cause of decay in the sandstones, and the sandstones, when they are very absorbent, generally become readily disintegrated in this manner. Sandstones are not very extensively used in London for building, but they are very much employed in many parts of the country.

The next group includes what we call limestones. Limestones differ more in their nature than sandstones do, and include different kinds of material. For example, there are the carbonates of lime pure, and the carbonates of lime and magnesia. First of all I will take the carbonates of lime. Some of these are perfectly crystalline, such as marble. Marble has a very close texture; it does not absorb water, and it is therefore little acted upon by it unless it contains acids. When sound it lasts a long time, but if cracked decay will enter in where the crack occurs. Marble is a very expensive stone, and the quantity of it compared with the other kind of limestone is small; but there is a good deal of a sort of limestone intermediate between marble and common oolites. This is generally hard, and not unfrequently contains thin strings of foreign substances, as silica, which interfere with its working. Such stones are found in Derbyshire, and belong to what geologists call the carboniferous or mountain limestone series. They are crystalline, but irregular, being partially cracked, and containing many fossils. A large majority of the limestones used in this country are oolites, so called because they appear to be made up of a number of eggs. These oolites are of various qualities; they are found in many parts of the country, and are commonly used for building, being in fact our common materials. There are several varieties of them, which are of different value; one of the best is Portland stone. These stones are made up of a number of little particles, which are themselves groups of smaller particles. These little particles are cemented together by carbonate of lime; and the whole stone is nearly pure carbonate of lime. Portland is probably the best building stone we have in England, but is dear, being hard, and expensive to work. St. Paul's Cathedral is built of Portland stone, and so is Greenwich Hospital; both being excellent examples. It is impossible perhaps to find a better specimen of this stone than the hospital presents. A few days before his death I was with Sir Charles Barry at Greenwich Hospital, and he pointed out to me the beautiful condition of the stone on the east face. It is indeed worth looking at as a specimen of the material, and is almost, if not quite, equal to the marble of which Milan Cathedral is built. There are many other good specimens of this stone in London, and of these the Reform Club is as good as any. If you look at these specimens of the better kind you will hardly recognise the decay that takes place. You must look at stones which have been a long time exposed, or else at an inferior quality of material. Bath stones offer a wonderful contrast to Portland, being almost as soft as cheese in the quarry, and can then be cut with an ordinary knife. I speak now of the stones in the quarry, where all stones are softer and more easily worked than when they have been exposed for some time to the air. Being exceedingly soft, Bath stone is therefore cheap; it is easily obtained and easily cut, but it does not wear well. Some specimens of Bath stone are to be seen in the recent restorations of Westminster Abbey, that have failed so completely as to be already a great deal worse than much of the stone that has been there for centuries. Within the few years that have elapsed since this stone was put up it has decayed entirely; and yet stones of the same kind, from nearly the same quarry—indeed, some from the identical quarries—have been used in the city of Bath, and are not much the worse after a century's wear. There is a difference in the quality of the stone, but there is also a great difference in the quality of the air to which stones are exposed. The rapid decay may however be partly attributed to the fact, that the stone used for Westminster Abbey had not been well selected, while perhaps that employed at Bath had been for some time exposed to the air before use. Bath stone is as I have said an exact opposite to Portland. But we have other stones that are bad. I do not know that I can mention a more remarkable instance than the stone which is obtained at Heddington, in the neighbourhood of Oxford. No one, I think, can have looked at some of the older buildings in Oxford without seeing what a bad state they are in, and how bad the stone itself must be. A vast quantity of stone has been obtained from time immemorial from some of the quarries in the neighbourhood of Caen, and some other places near. This stone has been brought over to England almost from the time of the Norman conquest. Part of Canterbury Cathedral is built of it, and it has stood very well. But other stones from the same or from adjacent quarries have gone entirely: they have failed so thoroughly, that it is impossible to conceive anything worse;—they are even worse than the Heddington stone in the worst cases in Oxford. Among other buildings lately erected in London of this stone, Buckingham Palace shows the decay as clearly as can be.

Limestone decays in a very simple way, and from the same causes alluded to when speaking of sandstones. First, there is an exposure to changing temperature, all the limestones being absorbent, and taking in a certain quantity of water. The water is driven in by rain, particularly in what appear to be the sheltered parts of the stone, beneath projections. Then cold comes, and even if the stone has been placed in the building as it lays in the bed, there will still be a tendency to throw off successive laminæ; but if put carelessly in the building, or fixed at right angles to the position it had in the bed, so that what was originally the plane of the bed has now become vertical, the effect will be that the whole face of the stone will peel off; and if the stone is cut into delicate ornaments it is almost inevitable that some of the planes of the bed would interfere, so that when expansion takes place the outer lamina of the ornament would break off and fall away. The moment that is done in any one place absorption becomes more rapid than it was before, and goes

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on with increasing rapidity. If however the stone lasts for a certain time without injury, the surface hardens. All stone is much harder after it has been exposed to the air for some time than it is in the quarry; and therefore, if it once gets into this state it may last, but if it is attacked early it will go. There is an instance of this to be seen in Mr. Hope's house in Piccadilly, which is built of a soft stone. It has been sheltered by putting leads over the tops of the exposed parts; and I have Mr. Charles Smith's authority for saying, that in consequence of that the stone has been preserved;—the water has been prevented from draining down into the stones, and in that way it has had time to harden. The water that is absorbed when limestone is exposed to the air is charged with acids, as I have already mentioned, and under these circumstances the stone acts as a kind of filter. A porous stone acts also in another way, decomposing the gases that pass into it. A certain though slow decomposition thus goes on, and the stone becomes actually destroyed. Very often this will take place even when it is not very apparent outside; and that is the case especially with some of the Heddington stones. At Oxford you will often see large scales breaking off from the surface of the building, although the outside is apparently pretty good. This is the result of that amount of decomposition and alteration that goes on within the substance of the stone itself.

Magnesian limestone is carbonate of lime and magnesia; ordinary limestone is simply carbonate of lime. Just as the common limestone when crystallised is very durable, so magnesian limestone when crystallised (in which case it is composed of equal parts of carbonate of lime and carbonate of magnesia) is in a more compact state than when earthy, and then seems to stand exceedingly well. In the districts where these stones are obtained, the churches built of them centuries ago are quite unaltered. But when the same stones are brought into our London atmosphere, although they appear to be just as good, and are exposed to very much the same influences, they begin at once to decay. It was owing to a neglect of the consideration of this matter that the magnesian limestone of Bolsover, used in the construction of the Houses of Parliament, has suffered so much.

Magnesian limestone differs from common limestone in the way in which it decays. Under the action of the causes already mentioned it decays whenever the two minerals are not perfectly crystallised together, and then it becomes disintegrated and powdery; so that in one block you will find portions which are perfectly hard, and other portions near them which are also hard, whilst between them you will find portions which are soft, and so disintegrated that the particles might almost be blown away by the wind. This has arisen from the way in which the material was originally crystallised, and from the difficulty that there is in producing a perfect crystallisation in a mass on a large scale in nature. The same kind of stone as at the Houses of Parliament was used in the new building at Lincoln's-inn, and it is even worse. It was also used in the construction of the Museum of Practical Geology, in Jermyn-street, and in that building there is not a faulty stone.

Practically, the causes of decay of these absorbent stones are connected with exposure to damp atmosphere, rendered impure by various acids and alkaline gases, and also by changes of temperature, especially above and below that of about 38 degrees, at which water attains its greatest density.

Numerous plans have been patented for coating and choking the pores of absorbent stones with preparations of various kinds. The almost invariable idea has been to render the stones as far as possible non-absorbent: this has been done by combining a certain proportion of mineral substance with oil or fatty matters. There is but one observation with respect to these: they all inevitably tend to decomposition, except perhaps those that are of a pitchy or bituminous nature. Bitumen is of a nature that does not decompose by exposure, and is permanent, but it is of so dark and disagreeable a colour that it completely destroys the appearance of stone, and renders it so unsightly that no one could venture to recommend it. Oil and fatty substances therefore are the only ones that have been used. One cannot help feeling, that if our stone buildings are to be painted till their character as stone is lost, it would be better to build them of a cheaper material, and use bricks and stucco at once. With regard to the patents that have been taken out within the last twenty years on subjects of this kind, out of seventeen before me eleven are simply mixtures of various substances with oils and resins, and are therefore essentially of the same nature. Others use the mixtures of mineral matters in oil, but none of them appear to have answered the purpose, and none of them are now employed at all. A mere mixture of things, not involving a chemical combination must fail. We must then either have some invention by which the pores of stone are permanently choked by a bituminous substance, not unsightly and not in any way subject to decomposition,—or we must find some mineral deposit which we can answer for, which will adhere firmly, and which will also be permanent; in other words, must put something into or upon the stone which shall be a mineral substance, closely adhering, and not subject to ordinary atmospheric influences.

It is a great many years since a suggestion was made by a French chemist, M. Kuhlmann, which was apparently very ingenious, and which to a certain extent answered the purpose. It was proposed by him to coat the surface of absorbent stones with silica. Silica, which is in fact a combination of a base which is called silicon with oxygen, is also called silicic acid; but the acid properties are so weak that they cannot be recognised by the senses, and its affinities for alkaline bases are very feeble. Silicic acid or silica is capable of existing in combination with water, and in combination with some alkalies is soluble: it is found in nature combined with water in some minerals, and when in tha state it becomes soluble by the action of alkaline carbonates, among the rest carbonate of lime.

As a natural hydrate or mixture of small quantity of water (about 3 or 4 per cent.), it forms part of some particular kinds of sandstone. It is also found in natural hot springs, and it is even found in common spring water,—no doubt by the action of carbonic acid. It is soluble in caustic alkali. It is soluble for example in caustic potash and caustic, soda not under ordinary temperature and pressure, but with a temperature of 300 or 400 degrees Fahrenheit, and under steam pressure. Under these circumstances there is no difficulty in dissolving it. You get a solution in this way, a mixture of silica and potash combined with water, and a tenacious though soluble fluid. If when in the fluid state you expose it to the action of ordinary air for a time, it hardens, becoming at first sticky and gelatinous, being then hydrate of silica. To become this it undergoes a certain kind of decomposition, parting with its potash to the carbonic acid of the air. In this form it was proposed to use the liquid silicate of potash or water-glass by M. Kuhlmann, whose process consists in the coating of absorbent stones with the solution in question, and he believed that after this treatment the stone would become coated with silica. Since it is known that silica laid on and dried is insoluble, he believed that he had secured a useful result: but he forgot that insoluble silica that had been deposited in that way is still capable of being acted upon by the alkaline carbonates. Therefore, even when thus deposited, still in the course of time the alkaline carbonates of the atmosphere would act upon it, and it would be a failure. But that is not all; for if, at the time of application the surface be not perfectly dry, or should a shower of rain fall upon it before it has time to harden, the effect would be destroyed, the preparation being washed away. So much for the process which Kuhlmann invented. It is right to say that M. Kuhlmann himself believed that when used in limestone a double decomposition would take place, the silicate of potash being not only decomposed by the carbonic acid of the air, but a part of the silicic acid combining with the lime to form silicate of lime. This would, however, be a work of time, which the weather in a damp climate would not permit.

Another process has been invented by Mr. Ransome. His plan was to decompose the silicate of potash and to produce a deposit of mineral upon it, which would adhere to the stone by a process of double decomposition. He considered that if a mineral deposit could be absorbed into the stone,—I mean if, after a solution was absorbed into the stone, it could afterwards, by a chemical combination caused by another solution subsequently absorbed, be decomposed so that a solid film would be everywhere deposited, and if this could be done in a very brief space of time, so that damp, air, and rain should have no effect upon it, then the object required would be attained. He was in the habit of manufacturing the soluble silicate on a large scale, and he thought that by combining it with the chloride of calcium (muriate of lime) he would get this double decomposition. This is the case because soda and potash have a weak affinity for silica, and lime a very stong one. Silica, therefore, parts very readily indeed with soda or potash to lime, whilst the chlorine would with great readiness pass to the soda. He therefore attempted the process; and I think you will say he attempted it with some

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success, at any rate so far as the experiment went. There is no obscurity about its general result, as it is simply a matter of experiment. The first thing he did was to satisfy himself that he could get a rapid deposit. In the two glasses before me, one contains a certain proportion of silicate, and the other contains a corresponding proportion of the chloride of calcium, so that the two shall combine and form solids. In mixing these I put the chloride of calcium into the silicate of soda. The result is that the affinity of the chlorine for sodium being greater than that for calcium, while the affinity of silica for soda is weak, a double decomposition takes place, the chlorine leaving the calcium to pass to the sodium, thereby forming soluble chloride of sodium or common salt, and the silicate of lime set free, combining to form silicate of lime or insoluble salt, which is immediately thrown down in a solid state. The proportion being properly taken, the whole of the water is taken up and made use of as water of solidification, and the salt can be subsequently removed by washing.*

We thus have silicate of lime rapidly formed, and being obtained in this way it is necessary to consider what the result would be in the solution of the problem before us. I need not say it is by no means sufficient to have one insoluble mineral deposit placed on the surface of a mineral, whether calcareous or siliceous. It is not only necessary to have that, since there must also be cohesion, and this cohesion must be sufficiently powerful to render the mineral coating preservative. It is absolutely necessary that the silicate of lime should be a material which, when put on a surface of stone, should not only remain there, but become permanently adherent. Experience, however, has long ago shown that a very thin deposit of this peculiar mineral, silicate of lime, does adhere with singular rapidity, and with the most remarkable tenacity, to particles of sand and stone with which it comes in contact. It is the film which produced gradually gives all its value to mortar, and which cements together the stones of which is formed what builders call concrete. Immediately on the deposit of the minute particle produced by the double decomposition of two minerals and formation of two others, this strong tendency to adhere comes into operation. The particles of silicate of lime newly set free immediately and firmly attach themselves to the particles or grains of which the stone is made up, not only surrounding them, but binding them to each other, just as when mortar has long been left to harden it is as difficult to separate the parts cemented as it is the solid brick or stone; this it is which gives its principal value to the method suggested.

I have laid on the table several specimens of different materials which have been treated in this way, and also some of the results after they have been exposed to decomposing agencies. Near me are two specimens of terra-cotta. One has not been treated in any way, and it is exceedingly absorbent, and we know from experience that terra-cotta soon becomes injured on exposure to the weather. The other has been treated by the processes I have mentioned, and if any one will take the trouble to scratch the surface, he will at once see the nature of the change. The surface has become excessively hard, and although when treated this way it is not necessarily non-absorbent, it can be made so by repeating the process often enough. If not made non-absorbent, however, it has become less capable of injury from exposure.

There is also before me a specimen of Heddington stone exposed to Ransome's process, and another specimen of the same stone not exposed to that process. Both of them have been dipped in acid. The surface of one is entirely gone; the surface of the other is not touched. There are also two specimens of Caen stone, one exposed to the process and the other not. Both have been subjected to the same amount of acid, and the result is that one stone is entirely destroyed and the other is not injured. There are several other specimens of Mr. Ransome's stones on the table, and the hardness of them will be at once recognised by anyone who will compare them with similar stones not so treated.

There is another process which I ought to mention, which has been partly carried into operation in the Houses of Parliament. It was introduced by a Hungarian gentleman of the name of Szerelmey. I can hardly with propriety say anything about it. I know too much and too little about it to be able to express an opinion. At the same time, if I did not mention it, it might seem as if I had not been aware of it. Mr. Szerelmey, at the suggestion I believe of Sir Charles Barry, asked me to look at his process, but he did not inform me what its preservative power consisted of, and although he intimated its nature, he evidently intended me to regard what I observed as confidential. All I can say is, that regarding it as a secret process, it is quite impossible for anyone to express an unqualified opinion of its value until time shall have tested its capabilities. It is, therefore, best not to speak of it at all until it has been exposed for a number of years to the action of the weather. Time must show what its value is, if the materials are not stated, and certainly an experience of not less than several years can be regarded as of any value, since ordinary paint or drying oil will preserve absorbent stones for that period.*

In the case of stone prematurely decayed, it decays with the utmost irregularity: adjacent stones become very soon in a state so different that no one could have supposed they were dug from the same quarry, and the whole surface is unsightly and disfigured. None of the nobleness and beauty of decay is seen in these cases. There is a decent and picturesque appearance not unfrequently met with in old buildings, which inspires respect instead of dislike. There is the hoary front of age, of which none complain. It is seen in the marbles of Greece and Asia Minor, in the limestones of Rome, and even in some of the porphyries in Egypt Time, we are told, devours all things. All human contrivances must submit to it, and as it is a natural, so it is often a beautiful condition. But premature decay, like an artificial ruin, has a poor and mean appearance. It does not give the idea of waning strength, but of absolute innate weakness. It is a *coup manqué*—a thing not merely imperfect, but unnecessarily imperfect.

It is important to remark also that such was not always the case. Many of our old buildings scarcely show incipient decay—many of these in large towns have decayed so as not to be unsightly. This, it is true must not be altogether attributed to the material, as such buildings if erected now of picked stone from the same quarries, would probably injure much sooner, owing to the much larger quantity of impurity in the atmosphere to which they are exposed. When a stone has been for some time exposed to pure air it hardens, and thus buildings, placed where we see them before the large town arose around them, have stood exposure better than they could do now. But there is reason to know that the selection of stone was far more careful formerly than it has been lately, and the result is manifest.

If the method of protection and preservation contrived by Mr. Ransome is successful, as it really seems to be, the softer and cheaper stones may be used. It is certainly the case that a hard, almost flinty surface is obtained by it, and that such surface is not acted upon by the acids which rapidly destroy the same stone when unprotected. For four winters stones thus protected have stood the action of the weather, and if it turns out to be as durable as it seems likely, from this and other trials on a large scale, if absorption is checked—so far at least as its injurious effects are concerned—or where absorption does not seem to be injurious, and if decay is thus arrested, then there are means at hand which cannot fail to have a great influence on decorative stonework, for the material most easily carved and sculptured is just that one which is most completely improved by the process.

* The lecturer, while performing the experiment, stated that by the time the lecture was over the whole of the contents of the glasses then liquid would be in a solid state, and added that unless it was removed before long, the solid silicate of lime formed would adhere to the glass so firmly that it would be very difficult to get it off.

* Since the above was delivered a correspondence has been printed by order of the House of Commons which renders some further observations desirable:—Mr. Szerelmey had not, I now find, allowed me to ascertain the real nature of the method he adopted, which consists in the use of soluble alkaline silicates, succeeded by a wash of bituminous matter also in solution. This was stated in confidence to Dr. Faraday, who, however, does not say that the application of the soluble silicates is succeeded by a second wash producing a deposit of silicate of lime. We are led to infer that the second wash is the bitumen only, and the object of this must be to shelter the surface while the alkaline silicate is undergoing slow decomposition and becoming converted either into hydrate of silica, or silicate of lime, just as by Kuhlmann's method. It would thus appear to be Kuhlmann's process with the addition of a bituminous and temporary sheltering surface. It still remains to determine whether by this process permanent protection is given, as if the deposit consists of hydrate of silica, the alkaline carbonates to which it must soon be exposed will no doubt destroy it. The temporary shelter of bitumen cannot be taken into account as having permanent value, although for the time it lasts it appears to be more efficacious than anything else. I observe that Dr. Faraday, in expressing a qualified opinion on the present appearance of the stone thus acted on, speaks "of the short and insufficient evidence now existing." It is indeed clear that the real value of the method of Kuhlmann depends on the nature of the deposit formed, and I believe it has not yet been determined what this is, simply because there has not been time enough given for the experiment. Complete exposure of a surface once protected by Mr. Szerelmey without any subsequent treatment for some years (four at least) could alone decide the question. The condition of the Speaker's Court, in the Houses of Parliament, will thus, after a time be a fair test of the value of his method.—D. T. Ansted, 26th May, 1860.

THE NEW SOCIETY OF PAINTERS IN WATER COLOURS.

THIS year's exhibition, the twenty-sixth at their Gallery in Pall-Mall, will maintain the good opinion to which its merits season after season fully entitle it. Indeed, with such members as Warren, Bennett, M'Kewan, Rowbotham, Haghe, and Corbould, it can hardly fail to be otherwise; and when all of these gentlemen contribute, as they do this year, the result is unquestionable. In our own department Mr. Haghe holds the first rank, both as an artist and an architectural draughtsman; both these qualities, as well as his thorough management of colour, are evidenced in his "Ghetto, Rome" (68), a most powerful work; and again in (86) the "Room of the Ambassadors, in the Ducal Palace, Venice,' which reminds us of some of his earlier productions. Mr. Chase sends, as usual, a goodly number of architectural subjects, some apparently in continuation of his illustrations of Haddon Hall; also the rural-looking lich-gate at Beckenham Church (25); the "Garden entrance at Roslyn Chapel" (135), a capital bit of design, with a bold segmental arch spanning and sheltering a doorway between two buttresses;—two views of Tintern, two of Furness Abbey, and an effective little sketch (306) of the "'Prentice's Pillar at Roslyn." Mr. Bennett exhibits eleven pictures, all of his accustomed excellence; and Mr. M'Kewan, a worthy fellow-labourer in the same school of landscape art, has no less than seventeen. (33) "The wild pass of Penmeaubach, near Conway, N. Wales," by Mr. T. S. Robins, is a skilfully-treated subject; but still better is Mr. Bennett's "View from Longleat (204), one of the most perfect specimens of unaffected colouring we ever saw, bearing marks of having been dashed off by a ready hand. Mr. Wykeham Archer's "Brinkbourn Priory, Northumberland (179)," is a well-drawn architectural picture; and Mr. T S. Boys has several of the same class, careful, but scarcely so freely handled. His "Remains of old England," as exemplified in the domestic half-timbered work at Shrewsbury, Tewkesbury, Worcester, &c., will be examined with interest. Carl Werner is a showy exhibitor, and sends some large drawings, but owing to the non-felicity of their subjects they fail to create a satisfactory impression, notwithstanding the elaboration with which they have been worked out. The president, Mr. H. Warren, has five pictures, stamped with his peculiar treatment; one especially (94) "The good Samaritan," is quite a novel interpretation of this oft-selected theme. Mr. Tidey's "Queen Mab" (224) is truly an artist's conception, grandly imagined, and, with a very few drawbacks, admirably expressed. Mr. Rowbotham's "Head of the Lago Maggiore" (215) is a large picture, clearly and cleverly limned, as is also his other view on the same "Lago" (313). Several little architectural gems, the productions of Mr. J. S. Prout, will not be passed without observation. Some of these, from Caen, are particularly good, and in (301) the sculptures on the "Porch at Ratisbonne" are nicely touched in. Mr. Howse, in his views at Rouen (114, 142), and in some English scenes, displays his accustomed ability; and Mr. Corbould's single picture (250), "Saul at Endor," is a fitting companion to the president's "Good Samaritan." We have omitted, we find, specially mentioning Mr. M'Kewan's two views at "Naworth Castle, Cumberland" (61, 277); the former, designated "a peep," is nearly all landscape, while the latter, showing the D'Acre tower, is a most delightful bit of architectural outline and colouring.

We could yet further enlarge, but that the limits of our space forbid. Our readers will have gathered that there is plenty to repay a visit to the Gallery, and we hope they will take an early opportunity of doing so, to judge for themselves.

LUDLOW CHURCH, SHROPSHIRE.

AMONG the churches of the West of England few can claim a more distinguished rank than that of Ludlow, either in antiquity, size, or beauty, though, from the comparative isolation of the place, both it and its venerable castle were but little visited till the Shrewsbury and Hereford Railway made the town one of its most important stations; and during the last two years the church has been subject to certain repairs and restorations, to which we shall now allude, after premising such historical remarks as could be gleaned from the few ancient records remaining. At the time of the original foundation of the castle by one of the Norman Earls of Hereford, or by Lacey his feudal vassal, the chapel in the keep of the castle served for the retainers located in or around it for accidental services, while probably the whole of what is now the parish of St. Lawrence, Ludlow, was then only a part of that of Stanton Lacy. The increasing number of men-at-arms, and the traders induced to settle around from the gain to be made, and the protection to be derived from the shelter of the castle, rendered it desirable to erect a place of worship in closer proximity than the distant church referred to. We accordingly find that a church really existed at a very early period, and although from the remains discovered during the recent alterations it must have been of considerable size,—consisting of nave, south aisle, central tower, probably some sort of transept, and a chancel,—yet in 1199, being found too small or from some other cause, the building was remodelled in the Early English style; the renovations, which extended apparently over a considerable time, being commenced (as not unfrequently happened) at the east end. The very curiously-planned hexagonal south porch, which possibly dates originally from this period, could scarcely have been finished before it was again pulled down, and rebuilt in the style prevalent from about 1220 to 1230, but the old entrance door from it to the church was retained. Next was rebuilt the north aisle, at about the time, and in imitation of, the fine south aisle at Leominster, with a west window whose detail was everywhere studded with ball-flowers, all the other windows being of simpler character. To this aisle succeeded probably the north transept in the Decorated age, of which date the north window is a remarkably fine specimen. Somewhat earlier than the erection of this transept there had been introduced into the chancel a beautiful arcaded tomb, seemingly of foreign (French?) design, with Early Decorated mouldings. After the north transept followed the alteration of the east window of the south aisle of the choir, and the building or rather rebuilding of the southern transept, as is evident from existing fragments. The windows here, as also the one at the east end of the nave aisle, are of the reticulated tracery so often found in Late Decorated work; and they probably furnished also some ideas for the designer of the large west window of the nave. On both the inside and outside of the transept gables may be discerned the mark of the pitch of the original early roofs.

The tower is a central one, rising as usual at the intersection of nave, chancel, and transepts. Below it is internally a parallelogram, but after it clears itself above the roofs and walls it becomes a square on plan, both within and without. This has occasioned, at the foot of the lantern windows, a considerable difference in the columns which are carried up at the angles to receive the wood groining; and, in order to render this discrepancy less perceptible, heavy wood beams, moulded, were placed round the junction, some of which rest consequently on the stone recess, while the others (on the north and south sides) are wholly detached from it, being only supported at the ends. But the really grand character of the tower is attributable to the noble arches on which it stands. Their mouldings are of the simplest Perpendicular kind, but from their boldness, and the lofty height to which they are carried, they constitute a most imposing feature in the internal perspective of the church; while on approaching nearer, the light and elegant lantern above contributes its share towards completing the effect.

The chancel screen, and those to the chancel aisles, are of oak, and of the most elaborate description, being full of panel tracery, cusping, carved work, and brattishing. Less ornate screens cross the transepts. The roofs are generally plain and good, but that to the chancel is handsomely moulded and panelled, having also a rich cornice, and well carved bosses at all the intersections. This roof is chiefly of the Perpendicular age, but some portions were repaired at a later date, in close imitation, as appears from records on the beams themselves. In this roof the emblems of the Evangelists are carved on four of the bosses with wondrous skill. Some indications of the original painting, too, having shown themselves on examination, this part of the decorations it is intended again to restore, and a commencement has been already made. The ancient stalls in the chancel are of the most beautiful Perpendicular detail, and, with their canopies behind, present a thorough study of that class of work, especially in connection with the chancel screen itself.

In removing and replacing the monument of the Corbet family during the late restorations in this part of the edifice, it became necessary to imbed into the wall the large corbel which supports the frieze, and, in so doing, the stone cut into proved to be part of a decorated open arcade belonging to a monument of great

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magnificence; while on making an opening for the pipe which supplies the hot water apparatus from the small vestry, some more of the lower range of panelling of the same, with sundry painted figures, became visible, and portions were taken out; other bits are still to be seen under the present window, turned inward as walling stone, which from their blue colour may easily be distinguished. It is strange that so exquisite a tomb should have been so wantonly destroyed. The south chancel aisle (locally termed the Lady Chapel) has part of a very beautiful east window of stained glass, forming what is called a Jesse window. The background of the figures is ornamented with squirrels, birds, fruits, &c. In excavating the floor of the chancel a considerable number of old encaustic tiles were found, among which were some Early English or Early Decorated tiles, and a considerable number of later date. The reading desk and seating in the chancel are all new, and in keeping with the pervading style of the church, though rather plain; the pulpit is, however, more enriched, and, being of stone, forms a prominent feature against the north-west pier of the tower. Several "corporation-seats," also, with their carved insignia and cresting, serve to vary the monotony of the ordinary framing.

The greater part of these improvements is due to funds raised among the parishioners themselves, but the restoration of the curious stone porch was undertaken by the Right Hon. Lord Boyne; the large west window of the nave (of seven lights) by Beriah Botfield, Esq., M.P. for the borough; and others by Sir C. Boughton, Colonel Herbert, &c., &c. In many of these stained glass has been inserted, as also in the lantern windows of the tower. The work of restoration being for the present completed, it is purposed to re-open the church on the 4th instant.

INSTITUTION OF CIVIL ENGINEERS.

GEORGE P. BIDDER, Esq., President, in the chair.

May 15.—The whole of the evening was occupied by the Discussion upon Mr. JAMES J. BERKLEY'S paper "*On Indian Railways; with a description of the Great Indian Peninsular Railway.*"

In commencing the discussion, it was remarked that the East Indian Railway extending from Calcutta to Delhi, with three branches, and a line from Allahabad to Jubbulpore, was 1338 miles in length, of which 295 miles were now open for traffic. There was only one tunnel, which was 300 yards in length; but there were viaducts of considerable magnitude, particularly those over the rivers Soane and Jumna, in which cases carriage roads were constructed under the railway, as well as over the Adjai, Moree, Keeul, and Tonse. Coal had been found on this line, which was used as fuel for the locomotive engines, and in which there was already a large traffic along the line. The estimated cost of this railway was £14,480 per mile, but the finished portions had been executed for £12,900 per mile. It had been calculated that the cost of the works would be increased by the mutiny to the extent of three millions sterling.

In reference to the Great Indian Peninsular Railway, it was stated that the estimated cost was about £10,000 a mile, but the opened portions had only cost £8713 a mile. The rolling stock was generally like that used in England. The engines to be used on the two Ghaut inclines had four wheels, with tanks and skid brakes. Between the years 1853 and 1859 the rate of wages for ordinary labour had been about doubled. This was a subject for congratulation, so far as the well-being of the population was concerned. Nor would its effect be to augment the cost of the line in the same proportion; for during the progress of the works mechanical appliances had been introduced, the workmen had learned their use, and had become more intelligent, and, by being better fed and protected were more valuable.

The Madras Railway, extending from Madras, on the eastern side of the Peninsula, to Beypore, on the western coast, with a line to meet the Great Indian Peninsular at the river Kristna, was 845 miles in length, of which 96 miles had been opened. The peculiar features of this line were the crossings of some of the principal rivers, and its construction without the intervention of contractors. It would be interesting to know the reasons that had induced this departure from the system pursued in England, where the judicious subdivision of labour introduced by the contract system had been found to result in economy and efficiency. The execution of the works on the Bombay and Baroda, and also on the Great Southern of India, was likewise undertaken by the engineers. The advantages of the introduction of contractors of capital and of experience into the Bombay Presidency, had been clearly stated in the paper.

The Scinde Railway extended from Kurrachee to Kotree on the Indus, for a length of 114 miles; and the Punjaub Railway from Moultan to Lahore and Umritsir, a distance of 250 miles. A line was also under survey from Lahore to Delhi. The difficulties to be surmounted in the navigation of the Indus, and the class of steamers and other vessels proposed to be employed, were well worthy of consideration.

The other lines were—the Bombay, Baroda, and Central India, extending from Bombay through Surat, Broach and Baroda to Ahmedabad, for a distance of 309½ miles, on which the bridges were composed entirely of iron; the Eastern Bengal, from Calcutta to Kooshtee on the Ganges, 108 miles in length; the Great Southern of India, of which 80 miles, from Negapatam to Trichinopoly, were under construction, and which it was proposed to extend to the Madras railway, near Errode, on the north, and to the coast at Tuticorin, on the south; and the Calcutta and the South Eastern, between Calcutta and the river Mutla, a length of 28½ miles.

The construction of railways in India had awakened a spirit of enterprise; had caused the country to be examined for its more valuable products, of which iron and coal had been found; had induced designs for docks, and for the improvement of navigation and of irrigation; had given employment, on an average, to one hundred thousand labourers; had led to an expenditure of fourteen millions of money within a few years, chiefly among the native population; and had involved the delivery into the country of seven hundred thousand tons of material, irrespective of contractors' plant, &c., costing about ten millions and a half of money. That they would ultimately lead to the development of the rich resources, and to the civilisation of the immense native population of India, could not now be doubted.

The number of men employed on the opened portions of the Indian railways in 1859, was 500 English and 7855 natives, giving an average of 16 men per mile. At this rate the lines now being constructed would give permanent employment to 77,000 persons. The fares in the Bombay Presidency in 1859 were; 1st class, 2½*d.*; 2nd class, ¾*d.*; and 3rd class, ⅜*d.* per mile. The speed of the trains, including stoppages, was from 16 to 20 miles an hour. The total number of passengers carried was 1,161,501, and the number conveyed over one mile, per mile of railway open, was 192,974; the average distance travelled by each passenger being 32·4. The total number of passengers, on all the lines in 1859, was 2,822,382, of which nearly 93 per cent. were third class. The average receipts in the Bombay presidency, for the year ending June 1859, had been for passengers £453, and for goods £464 per mile. It was evident that the goods' traffic had not yet been fully developed, as the lines were not continuous, nor had they reached the principal producing districts. The cost of working to June 1859, which had been since increased, was only 44·1 per cent. of the gross receipts, notwithstanding that the cost of fuel was 3 guineas per ton. The dividend on the expended capital was about 5·14 per cent. The East Indian had realised even a larger dividend.

In reply to the inquiry, as to the reasons which had led to the execution of the works on the Madras railway by the engineers without the intervention of contractors, it was stated that when the line was commenced, there were no large contractors available in that presidency, and it was thought better to proceed at once, rather than to enter into correspondence with the administrative body in England, which must have resulted in considerable delay. It had already been proved by experience in Bengal, that the natives could be readily organized on railway work; and as the large English contractors had no more information than the engineers as to the labour question, the purchase of materials, and other arrangements, there was no room for hesitation in returning to the primitive system, so successfully pursued in the cases of the Eddystone lighthouse, and the Stockton and Darlington and Liverpool and Manchester railways. Besides, in India scarcely any plant was required. The works were begun at Madras without any appliances from this country. The natives found their own tools and baskets for carrying the earth. Temporary rails were not needed, as there were no long "leads" from cuttings into embankments. The earthwork for the first six miles from Madras was let to a native contractor for rather less than one penny per cubic yard. The other parts of the line were let on a similar principle, in small sections, the sub-contractors being paid weekly. No difficulty whatever was experienced in carrying out this system within a reasonable distance of Madras.

With regard to the style adopted in the construction of Indian railways it was sometimes argued that the substantial had been selected in opposition to what was incorrectly called the American system. This was denied, for it had been the practice to take advantage of the cheapest and best materials to be found upon the spot; and where there was an abundance of good stone, and timber was dear, it was more economical to use stone and bricks than timber.

It was but fair to mention that the rate of wages and the price of work were much higher in the Bombay presidency than in the Madras. In the latter labour averaged per day—coolies, 3*d.*; women or boys to assist in carrying earth, 1½*d.*; carpenters, from 9*d.* to 10½*d.*; and bricklayers from 7½*d.* to 10½*d.* These rates were about the same as were now being paid upon the Great Southern of India. The ordinary price of earthwork was 1½*d.* to 2*d.*, and of masonry 7*s.* 6*d.* to 10*s.*, per cubic yard. The making of embankments, building of bridges, laying of the permanent way, and ballasting the road, cost about £1500 per mile, exclusive of materials and stations.

It was observed that the Calcutta and South-Eastern was so small, as hardly to be worth naming in an engineering point of view. It possessed

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however some interest commercially, the object being to open out a new port for the enormous and rapidly increasing trade of Bengal. The line extended from Calcutta to the Mutla, a distance of 28¼ miles. The dangers of the Hooghly were well known: its crowded state, and the expense and difficulty of its navigation, all rendered it necessary to seek another outlet. This was fortunately found in the Mutla, which was to a great extent free from the dangers of the Hooghley. The Mutla had a depth of not less than 24 feet at low-water spring tides from the proposed new port to the sea: it was subject to no bars nor dangerous tidal currents: the stream of tide did not exceed at any time 4 miles per hour: it had no freshes, no shifting sands, and no bar. It was interesting in an engineering point of view to compare the Hooghley and the Mutla; the former with a vast body of fresh water always passing down it, encumbered with shoals and shifting channels; the other without fresh water, a clear, deep, and permanent channel, kept open by the tidal scour alone. The system of executing the works without the intervention of contractors had been adopted, because the works were of that nature that no advantage could be derived from the large contract system. In this case no plant was required, and the native labour could be directed quite as well by the company's engineers as by those of a large contractor.

It was contended that in a distant country like India, where the engineer himself had no precise knowledge of what would be the cost of railway works, it was impossible to induce a fair competition among contractors, who would be tempted in making any offer to add a considerable sum to provide against contingencies which might arise. In the construction of Indian railways the best materials only should be employed, put together in the most substantial manner, for the population was very great, the traffic was likely to be heavy, and there was every prospect of a fair return for the outlay.

In closing the discussion, it was remarked that the paper was one of the most interesting and instructive that had ever been read at the Institution. It was a subject for congratulation that the results of the non-contract system had been so satisfactory in India; for although great supervision had been exercised by the government over the expenditure, there was nothing like personal interest to insure economy. Contractors might be said to be both bold and timid,—bold where the thing to be done was fairly understood, but timid where there were contingencies in the background. In introducing a new class of labour into a new country the engineer should pioneer the way, so as to ascertain the character of the elements on which contractors might subsequently found estimates. When that had been done fair competition might be relied on, and then the contract system might be introduced with advantage. Inferences of a useful character might be drawn from the comparison which had been made as to fares, and the average distance travelled by each passenger. The third-class fares in India seemed to be about one-half what they were in England, whilst the distance travelled by each passenger was respectively 32 and 12 miles. If the distance each passenger was conveyed in England could be increased, no doubt higher dividends would be realised, or lower fares could be charged. The intricate complications of railway companies had arisen from the contests for long fares. But it was believed that the real prosperity of a railway company was dependent more upon its own traffic; and that in general facilities should be afforded for the construction of lines in the districts traversed, so as to lead ultimately to an increase in the accommodation of the immediate population and for the general conveyance of traffic.

May 22.—The paper read was, "*On Breakwaters*," Part II. By MICHAEL SCOTT, M. Inst. C.E.

This communication was in continuation of a former paper, read in December, 1858.* It consisted of two parts,—the first being an account of the completion of the Blyth breakwater, the second a description of a new kind of breakwater.

It was stated that since the date of the former paper the breakwater at Blyth had been completed, with entire success, and with the greatest ease, notwithstanding a cross current of 3½ miles an hour. Having been exposed to the violent storm of October last, without sustaining the least injury, it was claimed that experience had afforded a complete answer to the objections made during the previous discussions to this kind of breakwater, which consisted of timber-frames deposited in deep water, planked and filled with stone.

It was shown that 20 lineal feet of the Blyth breakwater could be completed per day, and that the system of depositing frames was cheaper than piling.

It was also argued that such breakwaters were stronger, cost less, and could be erected in less time, than any arrangement previously in use. The round end was constructed on the principle of basket-work, and the advantages of this arrangement were pointed out. The cost of the breakwater, including the round end and the light-house, was stated to have been £11 per lineal foot. Four years' experience had shown that properly creosoted timber was not touched by the worm.

In introducing the new kind of breakwater it was observed that there were situations to which no structures hitherto used would be applicable, as there were conditions which none of them fulfilled. It was the consideration of these which led to the present design. Reference was made for the sake of illustration to Table Bay, Cape of Good Hope.

It was stated that difficulties had been experienced in finding a suitable breakwater for that locality, arising from the magnitude of the waves. A breakwater with a slope like that at Plymouth was not adapted for the locality, because the sea would roll over it, and because it was costly to construct and to keep in repair. The form of the breakwater at Alderney was not suitable, because the waves would break on the work, which could not be expected to withstand the blow of such enormous waves as those at the Cape of Good Hope. Besides, it was expensive and tedious to construct. The same observations applied to the forms of the breakwaters at Holyhead and at Portland, and if such a form gave way the harbour would be ruined, by the stones being strewed over the anchorage. A vertical wall built either from the bottom as at Dover, or from the depth below low-water at which stone ceased to be disturbed by the sea, was correct in principle; but the height of the parapet necessary to receive the rise of such waves, and the breadth of the work necessary for stability, would be so great as to render this form unsuitable. Moreover, as the waves were not only large, but were said to be breaking on the site of any harbour which could be arranged, the vertical wall was not applicable.

The new kind of breakwater was a modification of the wave-screen described in the former paper. Although similar in principle, it differed in the materials of which it was constructed, and it was applicable to deep water. It was proposed to deposit a bank of rubble stone up to the depth below low-water at which stone began to be disturbed by the action of the waves. Upon this bank would be built a face wall, up to low-water mark, and behind this wall long counterforts, the upper surface of which would rise from low-water at an inclination of, say 2 to 1, and extending back for a distance dependent upon the extent of the slope rendered necessary by the magnitude of the waves. These counterforts would be so far apart from one another as could be conveniently spanned by iron girders, suppose 20 feet; and the whole of the sloping surface would be converted into a sort of gridiron, by girders laid from counterfort to counterfort, at distances of about 18 inches apart. Supposing such a breakwater to be exposed to a heavy sea, whether the waves were breaking or not, the water would be projected up the slope, and would gradually drop through on its passage. This operation being diffused over a large surface, the water thus dropping through could not reproduce a wave, and the only effect would be a stream of water into the harbour. Thus it was stated that this form differed in principle from all vertical screens or gratings, which by permitting the wave to pass through at the same instant of time, had not the effect of destroying the undulation. It was desirable that the breakwater should be placed at an angle with the direction of the greatest sea, so that the wave should not only run up, but along it, especially in such a place as Table Bay, where the waves were of such magnitude. It was contended that this breakwater would be strong, durable, easily and quickly constructed, and cheap. A breakwater for Table Bay would cost, at prices current in this country, under £80 per foot run; and, what was important for a work executed abroad, the whole of the iron-work could be exported in a finished state.

The discussion upon this paper was continued throughout the evening, and not being concluded, the president announced that the subject would be re-opened at the first meeting of the ensuing session, in November next.

The paper "*On the Method of Computing the Strains and Deflections of Continuous Beams, under various conditions of load, &c.*," by J. M. HEPPEL, M. Inst. C.E., was stated to be of so purely mathematical a character as to be unsuited for reading. It would be published in the Minutes of Proceedings. The method proposed was, in its main features, identical with that given in Professor Moseley's 'Mechanical Principles of Engineering and Architecture,' and so successfully followed, in the deduction of practical results, by Mr. Edwin Clark, M. Inst. C.E., and others. The chief points in which the present investigation differed from others previously used were, that in estimating the action of forces more aid was derived from the theory of couples, and in considering the pressures on the bearing points, the two parts of each such pressure arising respectively from the portions of the beam on either side of it, were always kept separate and distinct. It was believed that in this way the means could be arrived at of dealing with all the conditions of a continuous beam, with little additional labour or complexity of calculation than if it were a succession of independent beams.

A paper was announced for reading early in the ensuing session, "*On the Measurement of Gas, and the Classes of Gas Meters in general use.*" By WILLIAM CROSLEY, Assoc. Inst. C.E.

This paper stated generally the facts connected with the early introduction of gas lighting, and its progress up to the present day, when the rental amounted to about five millions of pounds sterling per annum,—and the consumers to several millions of persons,—supplied by upwards of one thousand companies, corporations, or private proprietors of gas works.

* See *C. E. & A. Journal*, vol. xxii, p. 25.

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With a view of ascertaining the quantity consumed, otherwise than estimating by burner, the gas meter was introduced by Mr. Clegg and the late Mr. Samuel Crosley. This instrument, after having been in use for some time, and being modified by other persons, was still found not always to be relied upon for correct registration. The general complaints from the consumers of gas led to the passing of an act in the last session of parliament to insure a more constant inspection of the instruments for measuring gas.

Details of a series of experiments on meters of various designs and construction were given, showing how great an amount of error prevailed. At the same time remedial measures were pointed out, and discussion was invited upon the best instruments for use, and the most effectual systems of supervision.

NEW CHURCH, SOUTH LAMBETH.

At the rear of Albert-square, Stockwell, in the parish of South Lambeth, a handsome church in the Gothic style is now in progress. The structure is cruciform in plan, and internally is 122 feet long by 45 feet wide in the clear: the width is from outer wall to outer wall of the body of the church, there being no side aisles introduced, as is usual in ecclesiastical edifices in the Mediæval style, and consequently not any columns, which often interrupt the view of the preacher. The length from the northern to the southern walls of the transepts is 88 feet by a width of 36 feet, and the chancel is as usual recessed at the eastern end. Aisles being dispensed with, the main roof is necessarily in one span, and when completed will present a very fine example of carpentry. It will be constructed of deal, and embellished under its apex by characteristic tracery, the whole of which, together with its principal timbers, will be stained and varnished. All the other woodwork, including the open seats, will be executed in wainscot. Externally the material is Kentish ragstone, with Bath stone dressings. The style adopted is Decorated, of the geometric period. Most of the windows will have traceried heads, filled with stained glass.

For this fine structure the parishioners will be indebted to the Rev. C. Kemble, who has undertaken the erection and finishing of the edifice, including fittings and stained glass, at his sole cost. In close proximity to the church a commodious parsonage-house has been already erected. The whole is from the designs and is being carried out under the superintendence of Mr. John Barnett, architect, London. Mr. George Myers, of Lambeth, is the contractor, and Mr. W. Thomas the clerk of works.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Annual Report of the Council.

The Annual Report of the Council of the Royal Institute of British Architects has just been issued: from it we learn that,—

"The council have to record the decease of William Richard Hamilton, F.R.S., Honorary Fellow, a name known alike among diplomatists and the foremost investigators of all subjects connected with the fine arts of Classic antiquity; of Colonel William Martin Leake, F.R.S., Honorary Member, the patient and learned topographer of Ancient Greece and Asia Minor; of Benjamin Green, Thomas Penson, W. C. Stow, George Moore, F.R.S.; John Crake, G. Bish Webb, and Edward Lapidge, Fellows. Information of the decease of Peter Legh, Honorary Fellow, in the year 1857; and of the Conte Orte di Manara, of Verona, Honorary and Corresponding Member, in the year 1858, has only recently been communicated to the Institute. . . . Three Fellows, four Associates, one Contributing Visitor, and one Student, have retired; but the loss of these gentlemen is more than counterbalanced by the advancement of sixteen Associates to the class of Fellows, and the accession of twelve new Fellows, sixteen new Associates, and eight new Students; while fifteen candidates are now on the list, either for admission as new members, or for advancement from the class of Associates to that of Fellows. The Institute now consists of 173 Fellows, 139 Associates, 10 Honorary Fellows, 16 Honorary Members, 80 Honorary and Corresponding Members, and 12 Contributing Visitors. . . . The present Earl de Grey and Ripon has, within the last few days, most readily complied with the request made to him, and qualified himself to become an Honorary Fellow; expressing, at the same time, his gratification at the proposal, especially on account of the proof it affords of the regard felt by the members of the Institute for the memory of his uncle, the late President. . . . . .

The members unanimously agreed with the council in recommending Mr. Sydney Smirke, R.A., to her Majesty's gracious consideration, as a worthy recipient of that distinguished mark of royal favour, and of professional distinction, the Royal Medal for the year 1859. Under the highest sanction, the medal was presented, at the last ordinary general meeting, by our President, Mr. Cockerell, in terms highly complimentary, but fairly due to the recipient—now the third of the family successively elected to occupy a well-merited position among the Fellows of the Royal Academy. . . . . .

The removal from Grosvenor-street in June last was effected with very little interruption to the ordinary business of the Institute; and under the direction of the Arrangement Committee named in last year's report, these rooms were in order and ready to receive the members at the opening meeting of the present session. Thanks are particularly due to the gentlemen who have so efficiently done their duty as members of that Committee, as well as to Mr. Wyatt Papworth, and to Mr. T. Hayter Lewis, honorary secretary, for the time and attention they have bestowed on the arrangement and catalogue of the books, which now amount to several thousand volumes. . . . . .

The council feel it due to the honorary solicitor, Mr. William Leverton Donaldson, to call special attention to the value and importance of the services which he has rendered in attending to the settlement of the lease, in the course of which many questions arose demanding his time and his attention, both of which he devoted to them with that readiness and sincere goodwill which have ever distinguished his long-continued connection with this Institute.

Last year's report entered at some length into the question of certain changes which the Institute deemed desirable in the architectural branch of the Royal Academy. The views so entertained having been communicated to the Royal Academy, previously to the last annual meeting of the Institute, the result of the appeal was awaited with some anxiety. The official reply of the secretary of the Royal Academy, received only in November last, states however, 'that pending the existing uncertainty as to the future site and extent of the Royal Academy, it will not be possible to enter into any questions affecting changes in its constitution and regulations.'

Under these circumstances the council deemed it advisable to take steps to carry out the views expressed in the following paragraph of last year's report:—'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 heretofore considered necessary.'

In fulfilment of the promise given in the above paragraph, the council appointed a joint committee, consisting of themselves, the Board of Examiners of Candidates for District Surveyors under the Metropolitan Building Act, 1855, and the Professor of Architecture at the University College, London, to consider and determine on a scheme for an architectural examination, to be conducted by certain members of this Institute.

The leading features of the scheme have been recently forwarded to members in a printed form for their consideration, preliminary to the discussion of the subject at a special general meeting.

Though diversity of opinion may exist as to the manner of carrying these views into effect, the council feel that the rule now established that candidates should undergo the test of examination previously to admission, either into the learned professions, or into any branch of the public service, naval, military, or civil, should no longer pass unheeded by them, even were they not committed by the promise so distinctly made in their last year's report.

The same report, and that for the previous year, contains some remarks on the subject of competition, especially with reference to those of Barracks, and for the Government Offices in Downing-street. With regard to the latter nothing further has transpired officially beyond the announcement made by the Premier to the House of Commons, that no decision as to carrying out any one design would be formed without the consent of Parliament. With respect to the former it is understood that the architects who received the first prize for the cavalry barracks will be employed to superintend the execution of their design; in the same way as the architect of the first premiated design for the infantry barracks is now engaged, it is most satisfactory to state, in carrying that design into execution. In this instance good faith has been kept by the Government authorities—an example worthy of imitation by other authorities in all similar instances. The council feel much satisfaction in mentioning as a favourable omen of improvement in proceedings connected with competition, that they were requested by the authorities of the borough of Cambridge to name two architects, members of the Institute, to advise the committee appointed to select a design for the Guildhall and public buildings of that town; and that of three gentlemen who sanctioned the forwarding their names, one became the professional referee, and was subsequently called in to assist the Town Council of Southampton under very similar circumstances.

No occasion has hitherto arisen for calling together the committee appointed last year by the council to support the Institute's petition in favour of architects' copyright in their executed works, as well as in their publications, before a committee of the House of Lords, which was

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then about to investigate, it was understood, the subject of artistic copyright. But their good services may now be shortly brought into requisition should a measure promoted by the Society of Arts of London, entitled Artistic Copyright Amendment Act, which has only very recently been submitted to the notice of the council of this Institute, be introduced this session into the House of Commons; inasmuch as it contains a clause which legalises the copying of architects' executed works, while it affords protection to their publications.

Two of the vice-presidents having served during two full consecutive years now retire from office. Two gentlemen well known to the profession at large as well as to the members of the Institute, to which indeed they have already rendered most valuable services as office bearers and as individual Fellows, Mr. Thomas Leverton Donaldson, and Mr. Matthew Digby Wyatt, have expressed their willingness to fill the vacancies thus created, subject to the sanction of this meeting. . .

After twelve years' continuous service as ordinary member of council, during ten of which he has acted as joint honorary secretary, Mr. Charles Charnock Nelson feels justified in calling on some other Fellow and well-wisher to this Institute to relieve him of the responsibilities attached to the latter office, and of the constant attention required in the discharge of its duties. He is, however, willing to continue his services for a time as member of council, should this meeting think fit; our honorary solicitor having advised that no bar exists to his election. The council exceedingly regret that they will be deprived of his more active services, and they need scarcely say that they most cordially coincide in the movement which has been originated by some independent members, and warmly received by the Institute generally, to present him with a lasting memorial of their esteem. He will have the satisfaction on retiring of leaving the Institute in a most prosperous condition—one arising in no slight degree from his unremitting attention to the arduous duties of his office. Mr. James Bell, Fellow, who has been connected with the Institute during nearly the whole of his professional life, has kindly consented to undertake the charge relinquished by Mr. Nelson.

At the quarterly meetings of the board, thirteen gentlemen have presented themselves for examination under the Metropolitan Building Act; of whom eight have obtained certificates of competency to discharge the duties of district surveyor. The council, bearing in mind the gratuitous attention given by the board, trust that no gentlemen will come up for examination with any other view than that of becoming candidates for surveyorships under the Metropolitan Building Act; more especially as the scheme for an extended architectural examination, already alluded to, will, if carried into effect, give full opportunity to all members of this Institute to obtain certificates of competency, generally available for all legitimate professional purposes. . . . . .

The balance sheet, with the supplemental statement, shows greater receipts and corresponding disbursements than in the previous ordinary years.

The occurrence of isolated cases in which reference has been made for opinion on points connected with professional practice, confirms the impression existing in the minds of the council that a *more practical tendency would be given to the whole course of proceedings of this Institute*, if the members would more readily communicate the results of any such cases in which they may have been engaged; and if they would at the same time have greater confidence in submitting these matters to the consideration of the council and of the committee specially appointed to advise on all subjects connected with professional practice. A mass of evidence and of decisions would thus be brought together, to guide each member of the profession on the list of this Institute in his practice, on which he might rely for support when right, in any case referred to the decision either of an arbitrator or of a court of judicature."

SOCIETY OF PAINTERS IN WATER COLOURS (5, PALL MALL).

Remembering the peculiar excellence and number of the pictures, which constituted such an attraction last year, it could hardly be expected that the exhibition this season would equal its predecessor: it nevertheless presents a fair, if not an average display, and contains several productions of surpassing merit. There is always this pleasure, too, in feasting our eyes in the "Old Water-colour" Gallery, that one is not in danger of a surfeit from either the superabundance or extravagant variety of the objects before us, but there is usually just enough to secure attention for the time to which, to be profitable, such visits should be limited, and to induce a zest for returning to the spot with increased anticipation when occasion may again offer. Of architectural drawings perhaps there is scarcely so good a series as we sometimes see, although the names in the catalogue of Nash, Callow, Rayner, Fripp, Read, Burgess, and others, are in themselves suggestive of much that is sure to repay searching for. Among these names that of Mr. Burgess, jun. most frequently occurs, and we may point out several capital works from his hand, such as "The Lamberti Church, Münster," of which portions are shown in (67, 71), including its floridly-sculptured apse, a characteristic—essential, we might almost say, in continental churches. A fountain at Trèves (60) is chiefly noticeable for the elegant groupings of sculpture which almost too much enrich it, and the "Town-hall at Bremen," with the tower of the Dom Kirche, will be viewed with interest: so also will (49), "The entrance to the library, Rouen Cathedral," albeit this representation of it looks hard and liny.

Mr. W. Callow exhibits a highly finished and picturesque view in "Brunswick" (72); the "Place St. Pharailde, Ghent" (77); "Monmouth Castle" (101); the "Hotel de Ville, Calais" (244); and two or three pretty peeps from Venice. Mr. S. Reed, in (95), has a charming interior court of Linlithgow Palace; also in (65) a well detailed drawing of the "Tomb of Rubens, at Antwerp," —a strange mass of monumental architecture; the "Chapel of the Virgin" in another church at Antwerp (170), which shows its exuberantly-enriched high altar; and (186) a large and magnificent general interior of the same building (St. Paul's, Antwerp), in which the sculpture (which plays so important a part in the design) is rendered with admirable skill. Mr. E. A. Goodall also shows an interior (42) of the "Cathedral of Lierre, at Antwerp," well drawn, but coldly tinted. Mr. G. A. Fripp's "Piazza and duomo of Novara, Piedmont" (54), has all the air of truthfulness about it, and is moreover a good study. Mr. Nash carries us back to bygone ages with his "First of May in the 16th century" (59); his "Commonwealth troops in Arundel Church, Sussex" (24); and his "Monuments of the Essex family in Watford Church" (70). His "North Transept of Canterbury Cathedral" (93) does not please so well, for, though careful, it is crude in effect. "The ruins of the Temple of the Sun, at Palmyra" (105), form a picturesque group, to which Mr. Carl Haag has done full justice by the care and finish he has bestowed on their delineation.

We may also notice Mr. G. Dodgson's masterly picture, which greets us on entering the room,—"Christmas revels at Haddon" (7); Mr. Duncan's bold sea-piece (14), "The last man from the wreck;" Mr. Branwhite's "River Llugwy" (23); Mr. G. Fripp's large and exquisite "Pass of Nant Francon," between Bangor and Capel Cûrig (34), in which distance and atmospheric effects are so marvellously portrayed; "The forest" (76), by the veteran J. D. Harding; Mr. W. Collingwood's Welsh scenery (114, 171); and finally, Mr. W. Hunt's wonderful little studies from nature, of which he contributes several illustrations. His "Plums and mulberries" (204); "Mushrooms" (229); "Grapes, peach, and plum" (237); and "Apples" (238, 261), are each, in its way, all but perfection itself.

CONTINENTAL PUBLICATIONS AND INTELLIGENCE.

In our number for May an account was given of the *Encyclopedie d'Architecture*, and some extracts from the parts of that journal published in the earlier months of the current year. In continuation of that notice the monthly parts down to that for May have now to be described.

We find a notice of one case decided before the French legal tribunals, which has some interest to professional men in this country, as bearing upon the question of professional remuneration; and showing how the French law looks upon usage when brought forward to support a claim. It appears that an architect, by name M. Pigeory, had been employed by a client to prepare plans for a dwelling-house for families, containing twenty separate tenements, all identical, or nearly so, in arrangement. These plans he had prepared, and the building had been erected from them, but M. Pigeory had not been employed to superintend the carrying of them out himself. It was further proved that the plan was an almost exact copy of one which had been borrowed from another architect, M. Puteaux, who had himself previously built a similar dwelling-house. The first tribunal before whom this cause was tried decided that the customary remuneration was one and a half per cent on the outlay (an extremely low rate according to English customs), and that this was the amount to be paid by the client; one fourth of it being however handed over to M. Puteaux, the architect whose plan had been copied. On an appeal to a superior court this decision was set aside, and while the amount awarded to M. Puteaux for the information derived from his plan was confirmed, the sum payable to M. Pigeory was reduced from about £220, at which it had stood under the former decision, to a round sum of £100. The reasons assigned for this decision being, that it was the duty of the Court to decide, not upon professional or other usage, but upon the question of the value to the employer of the services rendered, and the time and trouble expended; and that as the work executed contained such a large amount of repetition, it ought not to be paid for at the same

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rate as if it had been a single undivided building. It seems difficult to comprehend how French architects can gain a living, if the customary remuneration for preliminary sketches, working drawings, and an estimate, all of which were in the present case furnished, be only one and a half per cent., and be liable to diminution in cases where there is any cause for supposing that the process of preparing them is less troublesome than usual.

Besides other excellent illustrations, a series of no less than ten plates are given, showing general plans and details of a new religious establishment, the convent of the Assumption, at Auteuil: this large number of illustrations enables one to comprehend singularly well the arrangement of the building and its detail; and the superiority of the plates contrasts markedly with the very moderate merits of a long descriptive account appended to them, which is discursive to the last degree. The arrangement of the plan is very simple: a large quadrangle apparently 32·5 metres (106 ft. 6 in.) square, with a cloister running quite round it, forms the central feature of the whole. Along three sides of this cloister are ranged various spacious apartments of differing dimensions and appropriated to various purposes, and in the centre of the fourth side is the entrance to the chapel. There is a basement story below the level of the cloister, and there are two stories of dormitories, of which the upper one is entirely in the roof. The whole arrangement appears at once simple and artistic. The style is Gothic, with a free introduction of modern appliances, new materials, and original decorative treatment. Referring both to the size and the modern taste of the building, the writer in the *Encyclopedie* describes it as "a building perfectly original, the largest and perhaps the most important of its style that has been erected in Paris, possibly even in France, for such purposes." The details certainly display much novelty and skill, but they are closer to the old types than those of the modern school of Gothic buildings in this country, and it would probably be found on a careful comparison of Auteuil with such a building as the Oxford Museum, that if there be less caprice and affectation in the French work, there is at the same time less freshness and vitality. The most interesting novelty shown is the employment of lattice girders in iron of ornamental design, thrown across the apartments on the principal floor, to support the floor above; these girders are carried on corbels of wrought-iron of extremely nôvel and appropriate design, and well calculated to satisfy the eye by bringing down the line of the iron girder on to the walls. A further account of this building with some additional plates are to be given, and we may have occasion to notice it again. The architect is M. Aymar Verdier.

A copy of the instructions to competitors for a bathing establishment at Spa is included in the April number. As is the case with many of the great competitions on the continent, a bill of quantities in detail is required to be furnished, to enable the judges to test readily the accuracy of the competitor's estimate. A list of prices at which the items in the bill of quantities may be assessed is appended, and is worth notice, not only as illustrating the difference in cost between building operations in this country and on the continent, but also because it shows that a system of estimating without going into minute details may be supposed to be in use there, such as formerly was practised in England, and is indeed retained in country districts, although in most busy localities the extremely elaborate and systematic plan of London surveyors is now more or less adopted. As examples, prices are quoted for flooring, inclusive of joists and plates, for ordinary staircases, at per tread and riser, inclusive of handrail, &c., and for a window and frame of a fixed height, but no width specified, inclusive of fixing, glazing, and painting. The price put down for stone and marble cutters, and plumbers, is 3·50 fr. (2s. 11d.) per diem; for masons, carpenters, joiners, slaters, &c., 3 fr. (2s. 6d.), and for labourers, 1·75 fr. (1s. 5½d.) per diem.

Les Archives de la Commission des Monuments Historiques is a work published in Paris by order of the French government, and, as it appears in parts, though published somewhat irregularly, it may occasionally be desirable to notice the contents of new parts as they appear. In the present account it is proposed to describe the nature and object of the work rather than any of the plates it contains, and these cannot be better explained than by quoting the following passages from the preface:—"Considerable sums of money are annually devoted by the government to the maintenance or restoration of those monuments of the classical and middle ages which are so numerous in the greater part of our provinces. These works are never undertaken until the commissioners of historical monuments appointed by the minister of state have made a report upon them, accompanied by a statement, plans, and views showing the condition of the buildings, and the repairs they require. These iconographic works, executed by the most talented of our artists, have been for the last fifteen years accumulating among the records of the commission, and form a collection of the highest importance to the history of art, and embody a mass of information the possession of which will be indispensable to the conduct of such restorations as at a more or less distant time will become requisite. The minister of state of his Imperial Majesty has formed the wish that documents so precious should no longer remain unknown and all but inaccessible to archæologists and artists, and has charged the commission to prepare for his approval a first list of monuments of which complete descriptions can be published within a period of ten years." The writer then proceeds to refer to the necessity of making a selection, and to the difficulty of doing so on account of the great number and high excellence of the "monuments" of France,—employing the word monuments not in the restricted sense commonly given to it in our language, where we most usually employ it only to designate a memorial of some deceased person, but in the more extended and juster sense, which embraces all those buildings and other works of human art and skill which remain to us as memorials of past ages.

The commission, it is stated, not having funds at its disposal sufficient to enable it to interfere in all the cases where its help is requested, has rigidly made it a rule "carefully to avoid an exhibition of partiality for any one style, or any one period in art, but in recommending buildings to the liberality and care of government, to select such as may be considered types in architecture, and mark the progress or decadence of that art." If it was impossible to save all the monuments of France from decay, it seemed necessary at least to preserve models for our artists of all the systems that successively have been adopted. Similar reasons have dictated the list of buildings which the minister of state has determined to publish;" these buildings are forty-three in number, and are to include, besides the finest Roman remains, and the most beautiful Romanesque and Gothic churches, other early buildings of a more archaic interest. Together with these and other religious buildings, illustrations of military and domestic architecture are to be given. The best talent is to be engaged on the execution of the plates, and in each case the architect whose drawings are engraved is to assist in superintending the preparation of them for publication. The accompanying letter-press, which is very brief, is restricted to a few statements respecting dates and historical facts such as it may be valuable to know, and which the engravings alone might not furnish.

This attractive programme has hitherto been worthily carried out. The work is in folio size, and the engravings, upon which the main interest of it centres, are executed in line with the highest finish. Those who had the good fortune to see at the General Exposition in Paris in 1855, a large number of these drawings, which were lent for exhibition by the commission, will remember the marvellous accuracy and elaborateness with which they were prepared, and will know how to value the possession of engravings from the choicest examples in the series. Having now brought this national work before our readers, we will in our next describe some of the buildings illustrated in it.

INVENTIONS RECENTLY PATENTED.

COATING METALS.

A. Whytock, London, *Patentee*, Oct. 11, 1859.

Sheets of metal have hitherto been coated by dipping them separately into the molten metal or fluid substances used. For various purposes lengths of coated sheet metal are required greater than the length of a single sheet, and in such cases it has been usual to connect several sheets together by grooving or rivetting, after they have been separately coated. This invention consists in combining sheets of metal together at their edges by any of the ordinary means before they have been coated; or such connecting of the sheets may be only temporary where it is desired simply to obtain the advantages of a more continuous process of dipping a series of plates or sheets into a coating fluid. The joined or connected series of plates or sheets are immersed in succession into the bath of melted metal, by which not only will the general surfaces be coated, but the permanent joints will also be coated, and the joints or seams thereby more advantageously made, and at the same time the connecting of several sheets or plates together before coating them will facilitate their being moved into and from the melted coating metal, and will also facilitate the movement of a succession of plates into and through a hot chamber, in order that they may become heated, and be caused in passing out of the hot chamber to enter the flux (floating in the bath of coating metal) in a more highly heated state, whereby the coating of the sheets or plates in some cases will be more effectually accomplished. By thus connecting several sheets or plates of metal, the manufacturer will be enabled to supply his customers with great lengths of coated sheet metal, and the user will be saved much of the trouble of connecting the parts; and the manufacturer, by connecting the sheets or plates permanently or temporarily, will be advantaged, by rendering the process of coating more continuous as compared with the coating the sheets separately.

Claim.—The subjecting of sheets of iron and other metal, when connected together into a long or continuous sheet, to the process of coating.

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LOCKS.

G. PRICE, Wolverhampton, *Patentee*, Oct. 14, 1859.

This invention as described by the patentee consists of a novel and simplified arrangement and construction of certain parts of locks, so as to prevent the possibility of picking by what is known as the "tentative process," or feeling the position of the gatings of the levers by applying pressure in any way to the bolt.

Since the Great Exhibition of 1851 it has been admitted that the principle on which the picking of locks depends is, that whenever pressure can be applied to the bolt in such a manner as to indicate the points of resistance to its withdrawal, such a lock can be picked. Since this tentative method became understood and practised in this country, many inventions of a more or less complicated character have been patented to prevent it; but although most of them show that great ingenuity has been employed in their construction, yet from their complex movements, liability to derangement, unsuitableness for general purposes, and their expensiveness, nearly all have been abandoned by the respective patentees.

The security against picking by pressure obtained in the construction of the locks above referred to has been by the addition of a number of "limbs" to the parts (the bolt, levers, and springs forming the essential mechanism of a lock), and which have added in corresponding proportion to the complexity, liability to derangement, and cost. The lock now patented comprises the case, the bolt, levers and springs of an ordinary lever lock, and the security against picking is mainly obtained by the peculiar arrangement and position of its parts. The peculiarity of its action may be explained thus:—the stump, the lever pin, and the guide stud of the bolt are so placed as to form the three points of a triangle, and on pressure being applied to the bolt in any other way than by the proper key the notched part of the safety plate is thrown upon the guide stud or runner stump, when the triangle becomes distorted or altered in shape in such a manner as to lengthen the side or distance between the main stump and the lever pin, the consequence of which is, that the faces of the front racks of the levers recede from the stump, and are perfectly relieved from its pressure.

This principle of construction is applicable to every description and size of lock. The patentee uses the ordinary "false plate" in every case, as the only additional limb, and this is simply laid upon the tail of the bolt to act as the detainer or safety plate. The patentee states that nothing but actual violence can throw this lock out of action; and as its security against every known mode of picking is obtained by the addition of one limb only to the ordinary lever lock, the construction allows the whole of the parts to be made very strong, which renders it in the same proportion more durable than others of its class.—*Claim.* The peculiar and novel arrangement and position of the parts referred to.

The second part of the invention is more particularly applicable to the locks used for the doors of bankers' strong rooms and the doors of iron safes; it consists of a method of supporting the shot-out bolt of the lock laterally to enable it to withstand the thrust of the handle and "follower" of the large lock. Many iron safes have been opened by applying a powerful lever to the knob or handle of the door, which causes the tail of the bolts of the large lock to press against the shot-out bolt of the small lock with such a thrust as to displace it, whereby the door is set free. The parts of the lock-plate are thickened up so as to form a groove or channel for the bolt to work in, which construction effectually prevents any thrust from displacing the bolt by whatever means the force may be applied.—*Claim.* The bolt working in a groove channel, as described.

The third part of the invention consists in the application of a hardened steel nozzle keyhole, more particularly applicable to the locks used for iron safes. Many safes have been opened by "tapping" the keyhole, so as to insert the fulcrum of a powerful cutting and boring machine, which is capable of cutting out a piece of the door over the small lock as large as a man's hand, whilst others have been opened by enlarging the keyhole sufficiently for the operation of a tool that cuts out, bit by bit, the works of the lock; but by the adoption of the hardened steel nozzle keyhole, which comes right through and is flush with the front of the door, such a liability is provided against. The internal construction and arrangement of this lock are the same as the patentee's "rim lock," with the addition of a gunpowder guard round the path of the key.—*Claim.* The application of a hardened steel nozzle keyhole as described.

The fourth part of the invention consists of a simplified arrangement and construction of latch, wherein either movement of the knob will effect the unlatching without the use of a follower, crank, or any extra part whatever. This is effected by sloping both the top and bottom edges of the bolt, and causing it to work either upwards or downwards, and the striking plate is formed with two notches or openings, one over the other, with a strong stationary piece between them, and which is also bevilled or sloped on its top and bottom edges (outwards), and thus the bolt in latching or unlatching has two openings through which it can pass in entering or leaving the striking plate or box. The bolt is sustained in its central position by one spring, which may be fixed into the latch bolt; when made as a mortise latch, it will do for either hand without any alteration.—*Claim.* The use of the double-bevilled rising and falling latch bolt, and the two-passaged striking plate, as described.

PREPARATION OF GUNPOWDER FOR LOADING ORDNANCE AND FIRE-ARMS.

J. H. BROWN, Romsey, *Patentee*, Oct. 15, 1859.

The object of this invention is to prepare gunpowder in compressed cakes or charges suitable for and to fit the various bores of cannon, rifles, muskets, and other fire-arms, without destroying the granulations of the powder or injuring its explosive quality, so that the powder and charges thus prepared may remain in store in suitable cases for several years without deterioration, and when used the whole charge may be deposited in the breech of the piece without confining it in paper or other extraneous material, and yet without any loose grains lodging in the grooves of rifled cannon or other fire-arms. In preparing the powder a solution of spirit which will not act prejudicially on the gunpowder is employed, containing gumaceous matter: it is deposited in moulds of the necessary form and size for containing the required charge, and compressed into a cake or charge. The pressure is regulated so as to bring the grains of powder into close contact, and cause them to adhere together, without destroying the granulations. The solution is applied to the powder by spreading it evenly on the surfaces of plates or cylinders of metal, and sprinkling the grains of powder over the plate, allowing it to adhere thereto. The powder so adhering is then removed by scrapers from the plates or cylinders, and deposited in moulds suitable for containing the required charges as before stated. On removing the compressed charges of powder from the moulds the spirit evaporates, and the charges become hard, and fit for use or for being stored away. The solution employed is prepared thus: 1 lb. of gum arabic is dissolved in 2 lb. of cold water, and ¼-lb. of nitrate of potash in five times its weight of cold water, which is added to the gum arabic, with 1 lb. of spirits of wine.

Claim.—The combining and compressing grains of gunpowder with an adhesive solution into solid cakes or charges for loading ordnance and fire-arms.

THE DECAY OF TIMBER, AND ITS PREVENTION.

A communication has lately been made to the *Journal of the Society of Arts*, by Professor Letheby, on the subject of the preservation of timber from decay. He refers to Mr. Burnell's recent paper on the Decay of Building Woods, and the means of Preventing it,* a subject to which the Professor has given much attention. He writes:

"Mr. Burnell does not attach too much importance to the process of creosoting timber, when he regards it as the most effective of all the processes known for the prevention of decay; for, in truth, the dead-oil of common coal-tar contains all the elements which are necessary for giving permanent stability to organic compounds, by checking decomposition, by opposing the processes of oxidation, and by destroying the vitality of the lower forms of animal and vegetable life. If, indeed, the application of creosote to timber has ever failed in preventing decay, it has been because of the improper use of it, or the use of an oil which has not contained a due proportion of its most effective constituent—carbolic acid. This it is which is chiefly concerned in strengthening the weak affinities of the young or immature constituents of wood. It coagulates the albumen and gives firm-

See *ante* page 191.

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ness to the cellulose matters that are so prone to decay, and which communicate by a sort of catalytic influence, their decomposition to the neighbouring and more mature tissues. So powerful is the antiseptic property of this acid, that when separated from coal-tar, it will at once arrest the decomposition of every kind of organic matter. I have seen it stop the putrefactive changes of sewage and cesspool matter instantly, and it will even stay the more active decomposition of putrefying animal flesh. It is to be regretted that all samples of dead oil do not contain a like proportion of this valuable constituent. I have found that it ranges from 0·50 per cent. to rather more than 6 per cent. of the oil; and as the value of the oil is dependent on the proportion of this acid, it is a matter of some importance to know how its presence can be discovered. A rough estimate may easily be made by shaking up about half a pint of dead-oil with its own bulk of a rather weak solution of caustic potash. After standing for a little while the oil will separate, and the potash solution of the carbolic acid may be poured off. On acidulating this with sulphuric acid, the carbolic acid will separate like an oil, and it may be known by its creosote-like odour.

Another important constituent of dead oil is the hydrocarbon, which gradually discolours the oil and thickens it by absorbing atmospheric oxygen and forming a solid pitch. This operates in preserving wood by appropriating the oxygen which may be within its pores, and so checking ligneous eremacausis. The resinoid body which is formed shuts up the pores of the wood and effectually protects it from the action of air and moisture. The presence of this hydrocarbon may be known by the darkening, and, as it were, drying of the oil, when it is put upon white filter paper and exposed to the air. In the distillation of the oil this compound comes over most freely at the time when the naphthaline distils: and as far as my experiments have gone, I am led to think (that charged with most carbolic acid, and the resinifiable hydrocarbon) comes over at from 360° to 490° Fahrenheit. The carbolic acid is most abundant in the runnings at or near to the first temperature, and the media for holding them in solution or applying them to the timber at the last. Naphthaline and paranaphthaline, or salts, as they are sometimes termed, will of course come over at these temperatures; but as these substances are of no value whatever in preserving timber, they should be separated as far as possible by submitting the oil to cold and to the action of time. Dead-oil should not be exposed to the air more than is necessary, in order that oxygen may not be absorbed and the oil thickened and discoloured. Lastly, I may say that carbolic acid and the hydrocarbons of dead-oil are among the most powerful poisons to fungi, and acori, and all the lower forms of organic life. The oil therefore acts as a physiological preservative of timber. In point of fact its preservative action is of four kinds:

1. It coagulates albuminous substances, and gives stability to the constituents of the cambium and cellulose of the young wood.

2. It absorbs and appropriates the oxygen which is within the pores of the wood, and so checks, or rather prevents, the eremacausis of the ligneous tissue.

3. It resinifies within the pores of the wood, and in this way shuts out both air and moisture.

4. It acts as a positive poison to the lower forms of animal and vegetable life, and so protects the wood from the attacks of fungi, acori, and other parasites.

No doubt the action of the oil is injurious to higher forms of animal life. It is even offensive to ourselves, and hence the objection to its use in the interior of buildings. But I am led to think that this objection may be overcome by the use of agents, which, like nitric acid in its action on the benzole of the lighter oil of coal-tar, may give to the dead-oil a less offensive, if not a positively pleasant odour. When this is accomplished there can be no objection to its use in the interior of buildings, or for the preservation of ships."

THE ROYAL VICTORIA BRIDGE, MONTREAL.

In consequence of particulars which we deem it necessary to lay before our readers in connection with the Victoria-bridge not having been received in time for publication this month, we are compelled to postpone the second notice of that great work until our next issue, when we purpose giving further illustrations—including an Elevation and Section of one span, with other details—in addition to those which appear in this number.

COLONIAL PATENT LAW.

By F. W. Campin, F.S.A.

(*Concluded from page* 184.)

Upon a careful review of the state of the law of patents in the British Colonies we shall find it to consist of a heterogeneous mass of legislative enactments and local customs: some having their bases in the law of patents as it stands in the United Kingdom; others, as the Canadian and North American laws generally, being eliminated by various readings of the law in force in the United States; and some few colonies having no laws, properly so called, as in the West Indies, but merely recognised customs, making special local enactments from time to time, to protect particular inventors in the property in their inventions. Hence the British inventor, who may consider his invention applicable to the wants and wishes of his colonial fellow-subjects, has to run the gauntlet of these colonial difficulties before he can take up his proper position. But the greatest difficulty of all is, perhaps, that there is no provision made to give the British inventor time to ascertain if it be worth his while to encounter the great expense of securing the property in his invention in the colonies, and getting it introduced there; for it should be always borne in mind that it is a matter of considerable expense and difficulty to get an invention introduced into public use anywhere. It is true that in the East Indies twelve months from the date of the British patent is allowed as the latest term within which the application for a patent shall stand good; and in the West Indies, and other places, where the process is by special legislative enactment, doubtless the difficulty may be met. But what is really wanted is an arrangement similar to that which exists in the United States, where the law allows a patentee in another country a delay of two years from the date of his first patent.

All this appears scarcely capable of adequate remedy whilst our colonial system remains what it is, for nothing short of a congress or board, which shall have power to settle questions affecting the mutual interests of the colonies and the mother-country, can be expected to satisfactorily adjust such matters. It might however be proposed by our colonial minister to each of the colonies that two years' time to put in the claim for a patent should be allowed to British patentees: and he might without the sanction of the colonies undertake to officially transmit the applications of inventors for colonial patents with his despatches, by which means in many cases much expense would be saved to inventors.

REVIEWS.

Curiosities of Science. Second Series. By John Timbs, F.S.A. London: Kent and Co. 1860.

It cannot be said of the *multum in parvo* nature and excellency of Mr. Timbs' books, that they are among the "things not generally known," for by this time their reputation is widespread, and the author's name as familiar as a "household word." The second series of 'Curiosities of Science,' now before us, and which has just reached its second thousand, completes the anecdotic illustrations commenced in the first series; at the same time forming the sixth volume of 'Things not generally Known familiarly Explained," and concludes that design. The main idea of these little volumes, it need hardly be remarked, has been to seize upon topics imperfectly understood, and to convey, in an attractive form, information beyond commonplace. With this aim, recourse has been had to an immense variety of sources, and the results have been so well condensed and arranged, that one is at no loss to designate the series as among the very best and most useful that have ever been compiled. The present volume is devoted, in the main, to chemistry, its students, and professors. In the earlier portion it treats the subject retrospectively and historically, illustrating the profession of alchemy in brief biographical notices of its practitioners; then tracing the transition from alchemy to modern chemistry, and endeavouring to distinguish the real from the ideal,—the founders of a great science from the charlatans of low artifice and imposture. Among other matters incidentally alluded to, we find various items of information as regards the chemical analysis of certain building materials, interspersed with piquant scraps bearing on archi-

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tectural practice, and kindred subjects, a few of which are subjoined.

The Manufacture of Iron.

"Of all the metals iron is the most widely diffused, the most abundant, and the most useful. Hence the processes of its application are the most numerous; and their history carries us back to the remotest ages. Mr. Arthur Aikin mentions as a curious fact that cutting and even surgeons' instruments were found in the excavations at Herculaneum and Pompeii made of *bronze*, though some were also found of iron; from which it is to be concluded, that at this period (about the year 59) the great superiority of iron over every other kind of metal in the manufacture of cutlery was only partially acknowledged. Sir Gardner Wilkinson informs us that iron was known in Egypt at a very remote period; and the butchers sharpening their knives on a bar, which, from its blue colour, was evidently steel, is represented on monuments of the fourth dynasty, as well as on those of later times. The case-hardening of iron, by plunging it red-hot into water, is even mentioned by Homer.

The principal ancient seats of the iron manufacture in this country appear to have been in Sussex, and the forest of Dean, or Arden, as it was then called. It is known that iron-works existed in that part of Gloucestershire in 1238, because there exists among the patent rolls of Henry III. of that date one entitled 'De forgeis levandis in foresta de Dean.' Remains of ancient iron furnaces have also been found in Lancashire, Staffordshire, and Yorkshire. The iron-works in the Monmouthshire hills now extend about twenty miles; and mineral property here has risen from 5*s.* an acre surface-rent to £1500, or more, underground. In the vale of Taff, before the seventeenth century, rude attempts were made to smelt iron-ore; the bellows was worked by a water-wheel, and charcoal used instead of coke. Merthyr, the "iron capital" of the district, is scarcely a century old. Here, at the Cyfarthfa works, are employed upwards of 4000 men, including colliers; and the strata of coal lie parallel with veins of argillaceous iron-ore. This is the great seat of the bar-iron manufacture for railways. The chief iron-works of Sussex were in the Wealden strata, whence the iron-ore was extracted from the argillaceous beds, and was smelted with charcoal made from the abundance of wood. At Buxted, near Lindfield, iron ordnance were made three centuries since. Up to 1720, Sussex was the principal seat of the iron manufacture in England; the last furnace, at Ashburnham, was blown out in 1827. Kent was alike noted for its iron; and the last great work of its furnaces was the noble balustrades and gates which surround St. Paul's Cathedral, London: they were cast at Gloucester furnace, Lamberhurst, and cost upwards of £11,202. 'In the middle ages, and down even to a late date, while Dudley and Wolverhampton were obscure names, the forges of Kent and Sussex were all a-glow with smelting and hammering the iron which the soil still yields, although it is not worth the while of anyone to work it. The discovery of the coal-fields of Wales and Staffordshire gave the Kent and Sussex furnaces their death-blow, leaving the country dotted with forge and furnace farms, and deep holes, now filled with tangled underwood, from which the ore was brought.' ('Saturday Review,' No. 182.) Kent and Sussex have no coal, and the iron manufacture left these counties when smelting with coal or coke began to supersede smelting with charcoal.

Foremost among the great improvers of the iron manufacture ranks Henry Cort, who, in 1783-4, introduced the flame of pit-coal in the puddling furnace, and the passing of wrought iron through grooved rollers instead of forging under the hammer; yet the inventor of these valuable improvements, and his descendants, have been deprived of their just reward.'

Chemical Effects of Interment in Vaults and Catacombs.

"Although much has been said and written on the decomposition of the human body after interment in the earth, but little was known until lately respecting the process and results of such decomposition when modified by the corpse being placed in a vault or catacomb.

In 1849 and 1850 Mr. Walter Lewis, by the direction of the General Board of Health, visited the vaults of the principal churches of London, noted the external appearance of more than 22,000 coffins, and the contents of nearly 100, and several times tested or analysed the atmosphere of the vaults. In no case did he discover the slightest trace of cyanogen, hydrocyanic acid, or phosphuretted, sulphuretted, or carburetted, hydrogen, except a very minute quantity of sulphuretted hydrogen in the air of a single vault, which contained but few coffins. The corroded parts of old leaden coffins were always found to be carburet of lead, with no trace of sulphate or sulphuret. Some of the coffins contained ammoniacal gas in large quantities, and others none at all; but with this exception, the contained air was nearly alike in all, being composed of nitrogen, carbonic acid, common air, and animal matter in suspension. When ammonia was present it overcame every other odour; when absent, the smell resembled that of a very putrid moist cheese. The result was the same, whether the interment had been made a few weeks or a century and a half previously, whatever the cause of the disease, or the age at which it took place. Out of all the coffins examined, but twenty of the leaden ones had been bulged by the pressure of the gases in the interior. This is only about one out of a thousand, and shows that the gases are formed very slowly. Mr. Lewis, from various inquiries, could not ascertain that a coffin had ever been known to burst suddenly from the pressure of the confined air. When one becomes bulged, it is customary for the sexton to make a small aperture in it, to which is applied a torch as an antidote to the noxious effect of the escaping gases. Several persons whom Mr. Lewis had consulted had heard of cases in which the gases had caught fire, but after searching inquiry he could not find one who had ever seen them burn.

Mr. Lewis infers from the experiments made by him in vaults and catacombs, that the deleterious emanations from those depositories may continue for a hundred years after they are closed; they are not rendered noxious by poisonous gases generated during the process of decomposition, but by the animal matter itself, with which, if ventilation is not allowed, the air becomes saturated; that nitrogen and carbonic acid, holding animal matter in suspension, steadily but quietly make their way through the pores of lead coffins, and by the same means to the open air, so that, at the end of fifty or a hundred years, nothing remains but a few dry bones, though the coffins are still sound and unruptured.

Mr. Lewis, in conclusion, recommended that 'interments in vaults and catacombs be no longer permitted, as they are but so many active volcanoes, constantly emitting poisonous effluvia; and that the use of leaden coffins should be entirely discontinued.'

Mr. R. V. Tuson, in the 'Philosophical Magazine' for April 1860, maintains that the substance obtained, as above, from leaden coffins is carbonate of lead—that it is anhydrous, contains but a small excess of oxide, and hence differs in composition from other carbonates of lead. It was found during the search for the remains of John Hunter in 1859, in the vaults of the church of St. Martin's-in-the-Fields, that many leaden coffins had been converted, interiorly, all but a thin outer plate or foil, into this carbonate."

Memoranda on the Strength of Materials used in Engineering Construction. Compiled and Edited by J. K. Wheildin, Civil Engineer, Washington, D. C.—New York: D. Van Nostrand. 1860.

This is a very useful little book, containing an abstract of the results of many of the most valuable and interesting modern experiments of Messrs. Hodgkinson and Fairbairn; besides tables on the strength of building materials, stone of different kinds, breaking weight of beams, &c. In the words of the preface—"Many valuable accessions to our knowledge of the strength of materials have been made within a comparatively recent period; the records however have been scattered through different books, periodicals, &c., not always accessible or convenient for reference. We have therefore endeavoured in this brief essay to bring together and arrange some of the more important elements, both old and new, so as to form an *aide memoire* for the engineer and architect, at the drawing office and elsewhere." We confidently recommend it to the practical engineer as a very handy work of reference, and as the production of one of our Transatlantic brethren and fellow-labourers we give it on our own part a hearty welcome.

THAMES EMBANKMENT.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—You did me the favour four years since (in your number for July 1856), to insert a paper on the above subject; and I should not now ask for a similar favour, but for an argument I have heard advanced, as really the only feasible one that could be urged for the construction of the lower-level intercepting sewer along the line of the Strand and Fleet-street; in fact, that its very enormity was its recommendation; that the results that must ensue from the forcing such an excavation against every engineering principle, would effect such mischief as would give an impetus to the employment of builders and artificers for probably half a century! But I cannot believe that there is so much uncontrolled malevolence, selfishness, and vice even in London. It is well to endeavour to control what there is, and therefore I write.

People fully engaged in business too often take narrow, it might be said prejudiced, views of public matters, such as this which now engrosses, and most properly, the general attention. Thus, the navvy would have all excavation and embankment; the builder, all bricks; the mason, all stone; and according to the fable, the tanner would have nothing but leather.

But the time has arrived for expanding the mind, and throwing aside such untenable views. That great man who has been so recently amongst us did not allow the woodmen and foresters of Canada to force on him their specific for protecting the great

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bridge at Montreal: neither should the men of the trowel and the saw be allowed to take the intercepting sewer from the Thames-side, its legitimate position.

Enough seems not to have been as yet made of that position; while the great difficulties, in fact the ruin, that a perseverance with the Strand (street) excavation would insure, seems not to be sufficiently taken into consideration.

To come fairly at the question which now seems to be the turning point, we may assume that the bottom of the low-level sewer may be about on an average 40 feet below the present level of the pavement; as many parts of the Strand, the Adelphi-terrace, &c., may be 30 feet over the river edge. It must be admitted that the excavation is either to be worked as a tunnel, without seriously interrupting the intercourse, or it is not. If as a tunnel, while the expense would be more than quadrupled, the security to overhanging buildings or the possibility of securing them would be still less, than in an open excavation, arched and filled in afterwards.

Then, if it is not going to be tunnelled, it might be well to inquire what compensation would be given to the houses in that great business thoroughfare, for precluding them, probably for more than a year, from in fact any possibility of carrying on their several present occupations, which alone enables them to pay the high rents they are under, and the many taxes for this and other purposes levied on them; and from what fund would the compensation be derived? All this money then should be wasted, or they are *not* to receive compensation; but British justice will scarcely condemn one part of a community to present and prospective ruin, by the dilapidation of their houses, for the benefit of the rest.

But more money would be wasted than the amount of the compensation. All the cost of sinking the street of the Strand down to the Thames-edge level would be wasted; and still more, the reversal of all the sewers in the cross streets now running down to the Thames; as, to reach the new low-level sewer under the Strand, of course they should be made to run the other way, at a sad and an extravagant waste of expenditure, and causing a ruinous interruption to the letting and the occupation of these private streets.

It may now be not amiss to inquire, what would be lost by so perverse a carrying out of old ideas, and running the main sewer right down the middle of the main street, as they did in the country towns some fifty years ago. There would be lost—

1. The rent of bazaars, restaurants, and places of business on the inner side of the proposed esplanade.
2. The rent of sites for shops and buildings on the street extensions.
3. Barge-dock reasonable charges, and on wharfage for additional accommodation.
4. Rent or purchase, during progress of works or after, of the railway line to be preserved throughout.
5. Rent or purchase of superfluous space outside such grounds as Whitehall, the Temple-gardens, &c., to be reserved for ornamental uses.

The appropriation of the sewage, being common to both arrangements, need not here be entered upon.

And now, Sir, requesting those who may require more detail to avail themselves of your number for July 1856, in which the subject is indeed twice brought before the public, I shall conclude with a few lines from that number, page 218, and from which I have quoted the heads I have above inserted. "The public who pay need not be uneasy under the anticipated pressure of the ultimate cost, if the works be honestly carried out and attended to. But they may rest assured that no project will give satisfaction to such a complication of interests that does not provide (for each side of the river)—1st, a low-water, and 2ndly, a below-low-water drainage; 3rd, a uniform river wall; 4th, an esplanade drive and promenade, connected with the principal streets; 5th, a railway site parallel to it; 6th, a series of small docks within the esplanade and rail line, to meet the requirements of the present wharfs and stores, and such improvement of them as opportunity and circumstances may render desirable; and lastly, provision for an entire deodorisation and solidification of the sewage, to be effected at once or at any future time."

As the southern embankment might be commenced at Lambeth, where a good quay already exists, the northern embankment might commence in continuation of the quay at Millbank, where so much is already well done; it might then continue along, down-stream,—the most convenient way for working; outside the Parliament Houses, perhaps 40 or 50 feet, and outside Whitehall,—to both it would be an invaluable advantage,—soon reaching the site of the proposed Hungerford railway bridge, where it would be desirable to preserve every facility for access to and from the proposed railway station. Carried even so far, the benefit would be at once seen by those having intelligence, and the proper influence,—and the thing would be supported and completed.—I am, &c. J. W., C.E.

Note.—Since writing the above, I have had the pleasure of reading over some of the principal evidence before Sir Joseph Paxton's parliamentary committee now sitting, and it is on the whole extremely encouraging and satisfactory: words cannot go farther than Mr. Bazalgette's testimony, that the embankment in connection with the low-level sewer "would be of enormous advantage;" but I think Mr. Bazalgette may under-rate the risk in going beneath structures not new or rigidly connected together, such as we read of our American cousins moving totally down street; but dilapidated, old, and altered, until cohesion may be said to be at an end,—yet while let alone they do mostly stick together. The London clay may be valuable for scooping through, but at times it might run too thin for a protection, as in the Thames Tunnel; a sandy vein might intercept, as in Victoria-street, or the work might unavoidably get too near a deeper part of the foundation, as at the Horse-guards; and thus, not only shop-fronts, but spires, like St. Clement's, might come down ringing by people's ears, when it would be too late to lament that the clay did not hold more stiffly. Capt. Morgan's objection answers itself;—the navigation would be improved: for, the less water let above the docks into the wastes now existing, the better would be "the tidal supply to those docks." Mr. Gisborne, it appears, fully appreciates the value of the sites and frontage to be gained, and no doubt has given the railway in connection with the embankment some consideration; but it is worthy of the utmost, as a railway from London-bridge to Pimlico Station would confer immense advantage on the community.—J. W.

NOTES OF THE MONTH.

Westminster Palace Works.—Mr. Cowper, the Chief Commissioner of Works, has stated that Mr. E. M. Barry had been asked by the Government to act as architect in finishing the works in progress at the Houses of Parliament.

Malvern Link.—The church at Malvern Link, Worcestershire, has just been enlarged, under the direction of Mr. Scott, to afford additional accommodation to 140 persons. The western end of the church has been taken down and lengthened one bay. The south aisle also has been taken down, widened, and constructed with a span roof with its own ridge, instead of leaning against the wall of the ridge, and the alteration is decidedly an improvement in all respects.

Rough Plate-Glass, not transparent, but well adapted for railway-stations and workshops, and for use in horticulture, is now made by a very simple means, patented by Mr. Hartley, of Sunderland. The sole secret consists in ladling rough glass directly on to a hot table near the melting-pot, in place of carrying it as heretofore out of the refining-pot to a cold table at some distance from the furnace. By this means rough plate-glass is now made in minutes, instead of hours or days; and in patterns stamped by the table, which becomes so hot as to keep the glass molten till stamped, and till one ladleful is added to another and imperceptibly joined to it, so as to form plates of any size. One glass-making firm is stated to have expended £25,000 in vainly endeavouring to use the ladle and to draw the table close to the rough melting-pot.

Diving Apparatus.—Important improvements in diving apparatus have been made and patented by Mr. C. E. Heinke, submarine engineer, London. His apparatus has been lately used at Spithead for submarine operations in connection with the fortifications there, and has given great satisfaction. It has also been very successfully employed at the works of the New Westminster Bridge. It is stated that the apparatus is completely under the immediate control of the diver, and that it enables him to remain for several hours under water at great depths without inconvenience, and with great freedom of action.

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New Conservatory, Kew.—The tender of Messrs. Cubitt for the erection of the great conservatory and winter-garden, in the pleasure-grounds and arboretum adjoining the Botanic Gardens at Kew, has been accepted by the First Commissioner of Works, and the structure commenced. It will be little short of 700 feet in length, and will probably be the grandest purely horticultural building in the world. It will occupy an extensive area on the right-hand side of the grand lawn avenue, leading from the palm-house to the pagoda.

The Victoria Station and Pimlico Railway.—This line, which forms a connection between all the railways south of the Thames and the Victoria station, now in course of erection at Pimlico, was opened on the 9th ult. This line of railway will afford access from all the railways south of the Thames to the western and central districts of London. The chief work on the line is the bridge over the Thames, which consists of four spans of 175 feet each, and is entirely constructed of wrought iron, with stone piers and abutments.

The New Equatorial Telescope at Greenwich.—The Astronomer Royal has invented at the Royal Observatory, Greenwich, a new and magnificent equatorial telescope. The size of the object-glass is nearly 13 inches diameter, and the length of the telescope about 14 feet. It is so nicely balanced on its axis as to be moveable vertically with the slightest touch, so that it can be elevated or depressed to the view of any object between the horizon and the zenith with such facility, that it seems as if it moved self-supported in air, without the least friction on the supporting pivots. The movement on the polar axis in longitude, bearing the telescope upon it, is a more difficult matter, and exhibits a variety of contrivances, indicating a thorough knowledge of the object to be attained, and the very highest ingenuity and scientific knowledge in carrying it out. By the beautiful application of these contrivances, the telescope and the vast framing by which it is supported, are carried round by a clock with the most perfect smoothness, so that in watching through a microscope the gradual onward movement of the minute scale, not the slightest unevenness or irregularity in the movement can be seen, and this, considering that the whole apparatus set in motion by the clock weighs many tons, is a proof of great skill and contrivance, and great perfection in the workmanship. The connection of the clock with the polar axis is not permanent, but is stuck in or detached with perfect facility in an instant of time, so that the astronomer using the telescope directs it in an equatorial or vertical motion with the most perfect command. If he desires to examine the object he has found, he attaches the telescope to the polar axis and brings the clock motion into operation almost in the same instant, which then moves the telescope equatorially in an opposite direction to the movement of the surface of the earth, so that the line of sight through it continues directed to that one object, whether it be the sun, the moon, any one of the planets or satellites, or any fixed star which the observer wants particularly to examine. Behind the object glass are perceived minute cobweb lines, which enable the observer to measure with accuracy the movement inherent in the object he is examining, such as its revolution on its axis, or the passage of a satellite across a planet.

The Atlantic Cable.—Intelligence has reached Boston that some fifty miles of the Atlantic cable has been lifted up to a point extending seaward fifty miles from the shores of Trinity Bay. Fractures were found in the cable just where they had been indicated by the instruments on shore.

Statue of Havelock for Sunderland.—Mr. Behnes has finished the model in clay of a colossal statue of General Havelock, to be erected at Sunderland.

Wivenhoe, Essex.—The church here, after undergoing a complete restoration under Mr. Hakewill, of London, at a cost of £3000, was re-opened on the 13th ult. The following is a summary of the work done:—The nave, originally only thirty feet long, has been increased to forty-three, by shortening the superabundant chancel. The arcading, which had been in a great measure destroyed, has been replaced, the north and south porches rebuilt, and the roofs renewed. A new font has been supplied, also altar-rails and oak benches. The pulpit and reading desk are of stone, and are given as a memorial to the lately deceased wife of the rector, with the addition also of a window. Besides these, two other windows are donations, as well as the entire communion furniture.

OBITUARY.

On the 10th April last, at Kossid, Scinde, Mr. Henry Scott, Civil Engineer, Scinde Railway.

On the 28th May last, in London, Mr. James Blake, C.E., M.R.I.B.A., at the early age of 32, when well-earned honours were beginning to be conferred upon him. He died of consumption, accelerated by hard study of his profession, to which he was enthusiastically devoted. He was a native of Ballinasloe, Galway, and was last located at Oswestry, Devon.

On the 10th ult., in the 70th year of his age, Mr. John Whichcord, sen., architect, at his residence, Maidstone, Kent. He was articled in 1806 to Mr. C. Harcourt Masters, architect, of Bath, and afterwards assisted the celebrated D. Alexander, by whom he was engaged on the great works at the London Docks, and subsequently at the gaol of Maidstone. Among his principal works were the large county lunatic asylum for Kent, the churches of the Holy Trinity and St. Philip, Maidstone, the Corn Exchange, and the Kent Fire-office. Mr. Whichcord was surveyor to the Medway Navigation Company, and executed on that river several extensive hydraulic works, particularly some difficult tidal locks, besides erecting a great number of bridges through the county.

COMPETITIONS.

Designs are required for a Clock Tower, to be erected in the centre of the High-town, Hereford; cost not to exceed £1000. Also, designs for a Clock-tower Entrance into the new market from the High-town; cost not to exceed £500. Premium, £30. Designs to be sent in by the 23d instant, addressed to Mr. R. Johnson, town clerk, Hereford. Particulars and block plan of the High-town, on application to Mr. T. Smith, Coningsby-street, Hereford.

Designs are required for a new covered Market, &c. on premises adjoining the Guildhall, Southmolton, Devon. Premiums, £25 and £15. Plan of site and further information may be obtained on application to Mr. R. Snow, borough surveyor. Plans to be sent to the town clerk by the 1st of August.

Architects of Great Britain, Ireland, and France are invited to furnish designs for New Houses of Parliament to be erected in Sydney, New South Wales. £600 will be awarded for the approved design, and £300 for the second best. The style of architecture is left to the competitor. Drawings and estimates to be sent under sealed covers, addressed to the Secretary of Public Works, Sydney, to the care of Messrs. William L. Merry and Co., 36, Cannon-street, E. C. (the commercial agents of the New South Wales Government), for transmission to the colony by steamer. General conditions, together with a contour plan, may be obtained on application to Mr. Weale, 59, High Holborn; Messrs. A. and C. Black, Edinburgh; Mr. H. Campbell, Argyle-street, Glasgow; Messrs. Hodges and Smith, Dublin; Messrs. Philip and Son, Liverpool: Messrs. Thompson, Manchester; or M. Amyot, No. 8, Rue de Paix, Paris. At each establishment photographic views of the locality may be seen. Mr. Weale will give such explanations as may be desired of him by personal application or by post. Designs to be sent in by the 1st of January next.

Designs are invited from Belgian and foreign artists for the erection of an extensive Bathing Establishment, and the construction of a monument, to be placed near the wells of the Pouhon Spa, Belgium. The estimated cost is 800,000f. The designs to be sent to the Communal Secretary of Spa before the 15th August next. 12,000f. will be divided among the authors of the best designs. The plans will be exhibited in Spa till the end of the season. The programme, topographical maps, price of materials, &c., may be procured for 2f. of the following booksellers:—Wollessi, Spa; Desoer, Liege; Office de Publicité, Brussels; Libraire Renouard, Rue de Tournon, Paris. These documents may also be found at the Belgian Consulates in London, Birmingham, Manchester, &c., and all over the continent.

Competitions Awarded.

The designs of Mr. T. Goodchild, F.S.A., architect, Guildford, have been selected for the works of the new Aldershott Cemetery.

Messrs. Peck and Stephen's design has been selected for the new Church to be erected at Hoyham, Kent.

The first premium of fifty guineas for designs for the enlargement of the Bristol General Cemetery, was awarded to Mr. H. F. Price, of Weston-super-Mare; and the second of thirty guineas to Messrs. Poole and Newman, of Sherborne. The designs were referred for decision to Mr. Underwood, architect. Bristol.

The designs of Mr. C. H. Edwards, architect, of London, have been chosen for the new Halifax Cemetery buildings.

The designs of Messrs. Haig and Lowe, architects, Glasgow, have been selected for the new Public Rooms to be erected at Kirkcudbright.

To Correspondents.

The letter of *An Engineering Pioneer on the "Grand Trunk"* is so inconsistent that we regret we cannot insert it. Claiming an originality of design for his friend, he concludes by pouring a torrent of invective on the results; rather paradoxical.

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BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Thirtieth Annual Meeting, held at Oxford, 1860.

OFFICERS.

President—Lord WROTTESLEY, M.A., V.P.R.S., F.R.A.S.

Vice-Presidents—The Earl of Derby; Dr. F. Jeune; The Duke of Marlborough, The Earl of Rosse, F.R.S., The Bishop of Oxford, The Dean of Christ Church, Oxford; Prof. Charles G. B. Daubeny, F.R.S.; Prof. H. W. Acland, F.R.S.; Prof. W. F. Donkin, F.R.S.

General Secretary—Rev. Robert Walker, F.R.S.;—*Assistant-General Secretary*—John Phillips, F.R.S.;—*General Treasurer*—John Taylor, F.R.S.;—*Secretaries for the Meeting at Oxford*—George Rolleston, H. J. S. Smith, George Griffith;—*Treasurers for the Meeting at Oxford*—Rev. E. Hill, Rev. John Griffiths.

THE Thirtieth Annual Meeting of the British Association for the Advancement of Science commenced in Oxford on the 27th June. This is the third occasion of the meeting of the Association in Oxford: the first took place in 1832, and the second in 1847. The Town-hall was opened as a reception room, and the Radcliffe Library for the purpose of supplying information regarding the proceedings of the meeting. A business meeting was held in the Town-hall, at which the Report of the Council, the Kew Report, the Parliamentary Report, and the treasurer's account, were read and received. The first general meeting took place in the Sheldonian Theatre, when his Royal Highness the Prince Consort resigned the presidential chair, after a few words on the part he had himself taken in watching and fostering the progress of science during the past year, and on the merits of his successor in the chair, Lord Wrottesley,—who then delivered the inaugural address, from which we extract the following:—

The President's Address.

Gentlemen,—If on taking this chair for the first time as your President I do not enlarge upon my deficiencies for adequately filling the responsible office to which you have done me the honour to elect me, I hope you will believe that I am not the less sensible of them. Your last meeting was held under the presidency of one not more distinguished by his high rank and exalted station than by his many excellent qualities, and the discriminating interest which he has ever manifested in the promotion of Art and Science. It was one of the most successful meetings on record. . . . .

This great University has advanced in the career of scientific improvement, but everything else has been somewhat thrown into the shade by the important event of this year, the opening of the new Museum. The institution of the School of Physical Science forms a most important feature in the recent changes, and will doubtless be productive of good results. Amongst other University changes, is that noble step, the institution of the Middle-class Examinations, whereby Oxford has furnished substantial aid to those more humble aspirants to knowledge, by whom a University education, however much desired, is quite unattainable. This movement has given the most unmixed and heartfelt satisfaction to all who have the moral and mental improvement of the nation sincerely at heart; and greatly do I rejoice that such a satisfactory proof should have been given of a desire to make University institutions a general national blessing. . . . . .

The science of *Astronomy*, whether we consider the surpassing interest of the subjects with which it is conversant, or the lofty nature of the speculations to which its inquiries lead, must ever occupy a most distinguished, if not the first place among all others.

In a discourse addressed in May 1859 to the Imperial Academy of Sciences of Vienna, by the distinguished astronomer Littrow, a very full account is given of the voluntary contributions of the private observers of all nations to the extension of the science of astronomy; and this discourse concludes with a remarkable sentence, of which our English amateurs may well be proud: he expresses a hope that on the next occasion in which he shall be called upon to dilate on the same theme, he shall not as then have to mention English names in such preponderating numbers.

At the beginning of the year 1820, when the Astronomical Society was founded, the private Observatories in this country were very few in number. The establishment of that society gave a most remarkable stimulus to the cultivation of the science which it was intended to promote. I can give no better proof of this than the fact that the 'Nautical Almanack' now contains a list of no less than twelve private Observatories in the United Kingdom, at nearly all of which some good work has been done; and in addition to this, some Observatories which have been since discontinued have performed most important services,—I may instance that of the two Herschels at Slough, and that of Admiral Smyth at Bedford.

It may not be uninteresting if I describe the nature and utility of some of the results which these several establishments have furnished to the world: I say the *world* advisedly, for scientific facts are the common inheritance of all mankind.

As to the peculiar province of the Observatories which are properly called "public," such as the far-famed Institution at Greenwich, their task is now more peculiarly to establish, with the last degree of accuracy, the places of the principal heavenly bodies of our own system, and of the brighter or fundamental fixed stars, which are about 100 in number. But in the early stages of astronomy we were necessarily indebted to public Observatories for all the data of the science. On the other hand, their voluntary rivals occupy that portion of the great astronomical field which is untilled by the professional observer,—roving over it according to their own free will and pleasure, and cultivating with industrious hand such plants as the more continuous and severe labours of the public astronomer leave no time or opportunity to bring to maturity.

The observations of our private observers have been chiefly devoted to seven important objects:—

First. The observing and mapping of the smaller stars, under which term I include all those which do not form the peculiar province of the public observer.

Secondly. The observations of the positions and distances of double stars.

Thirdly. Observations, delineations, and catalogues of the nebulæ.

Fourthly. Observations of the minor planets.

Fifthly. Cometary observations.

Sixthly. Observations of the solar spots and other phenomena on the sun's disc.

Seventhly. Occultations of stars by the moon, eclipses of the heavenly bodies, and other occasional extra-meridional observations.

And first as to cataloguing and mapping the smaller stars. This means the accurate determination by astronomical observation of the places of those objects, as referred to certain assumed fixed points in the heavens. The first Star Catalogue, worthy to be so called, is that which goes by the name of Flamsteed's, or the British Catalogue. It contains above 3000 stars, and is the produce of the labours of the first Astronomer Royal of Greenwich,—labours prosecuted under circumstances of great difficulty, and the results of which were not given to the world in a complete form till many years had elapsed from the time the observations were made, which was during the latter half of the seventeenth century. About the middle of the eighteenth century, the celebrated Dr. Bradley, who also filled the post of Astronomer Royal, observed an almost equally extensive Catalogue of Stars, and the beginning of the nineteenth century gave birth to that of Piazza of Palermo. These three are the most celebrated of what may be now termed the ancient Catalogues. About the year 1830, the attention of modern astronomers was more particularly directed to the expediency of re-observing the stars in these three Catalogues,—a task which was much facilitated by the publication of a very valuable work of the Astronomical Society, which rendered the calculations of the observations to be made comparatively easy; and accordingly observations were commenced and completed in several public and private observatories, from which some curious results were deduced; as, *e. g.*, sundry stars were found to be missing, and others to have what is called *proper motion*. And now a word as to the utility of this course of observation. It is well observed by Sir John Herschel, "that the stars are the landmarks of the universe; every well-determined star is a point of departure which can never deceive the astronomer, geographer, navigator, or surveyor." We must have these fixed points in order to refer to them all the observations of the wandering heavenly bodies, the planets and the comets. By these fixed marks we determine the situation of places on the earth's surface, and of ships on the ocean. When the places of the stars have been registered, celestial charts are constructed; and by comparing these with the heavens we at once discover whether any new body be present in the particular locality under observation: and thus have most of the fifty-seven

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small or minor planets between Mars and Jupiter been discovered. The observations however of these smaller stars, and the registry of their places in Catalogues, and the comparisons of the results obtained at different and distant periods, have revealed another extraordinary fact, no less than that our own sun is not fixed in space, but that it is constantly moving forward towards a point in the constellation Hercules, at the rate, as it is supposed, of about 18,000 miles an hour, carrying with it the whole planetary and cometary system; and if our sun moves, probably all the other stars or suns move also, and the whole universe is in a perpetual state of motion through space.

The second subject to which the attention of private observers has been more particularly directed has been that of double or multiple stars, or those which, being situated very close to one another, appear single to the naked eye, but when viewed through powerful telescopes are seen to consist of two or more stars. The measuring the angles and distances from one another of the two or more component stars of these systems, has led to the discovery that many of these very close stars are, in fact, acting as suns to one another, and revolving round their common centre of gravity, each of them probably carrying with it a whole system of planets and comets, and, perhaps, each carried forward through space like our own sun. It became then a point of great interest to determine whether bodies so far removed from us as these systems observed Newton's law of gravity, and to this end it was necessary to observe the angles and distances of a great number of these double stars, scattered everywhere through the heavens, for the purpose of obtaining data to compute their orbits. This has been done, and chiefly by private observers; and the result is that these distant bodies are found to be obedient to the same laws that prevail in our own system.

The nebulæ are, as it were, systems or rings of stars scattered through space at incredible distances from our star system, and perhaps from one another; and there are many of these mysterious clouds of light, and there may be endless invisible regions of space similarly tenanted. Now the nearest fixed star of our star system whose distance has been measured, is the brightest in the constellation Centaur, one of the Southern constellations, and this nearest is yet so far removed that it takes light, travelling at the rate of about 192,000 miles per second, three years to arrive at that star. When we gaze at it, therefore, we see it only as it existed three years ago;—some great convulsion of nature may have since destroyed it. But there are many bright stars in our own system, whose distance is so much greater than this, as α Cygni, for example, that astronomers have not succeeded in measuring it. What then must be the distance of these nebulæ, with which so much space is filled; every component star in which may be a sun, with its own system of planets and comets revolving round it, each planet inhabited by myriads of inhabitants? What an overpowering view does this give us of the extent of creation! The component stars of these nebulæ are so faint, and apparently so close together, that it is necessary to use telescopes of great power, and with apertures so large as to admit a great amount of light for their observation. We owe it more especially to four individuals that telescopes have been constructed, at a great cost and with great mechanical skill, sufficiently powerful to penetrate these depths of space. Those four individuals are the Herschels, father and son, Lord Rosse, and Mr. W. Lassell. That praiseworthy nobleman, Lord Rosse, began his meritorious career by obtaining a First Class at this University, and has, as you know, spent large sums of money and displayed considerable mechanical genius in erecting, near his own castle in Ireland, an instrument of far greater power than any other in the world; and with it he has observed these nebulæ, and employed skilful artists to delineate their forms; and he has moreover made the very curious discovery that some of them are arranged in a spiral form, a fact which gives rise to much interesting speculation on the kind of forces by which their parts are held together. It were much to be wished that observations similar to these, and with instruments of nearly the same power, should be made of the Southern nebulæ also; that this generation might be able to leave to posterity a record of their present configurations. The distinguished astronomer, Mr. W. Lassell, the discoverer of Neptune's satellite, has just finished, at his own cost, an instrument equal to the task, mounted equatorially; and I am not without hope that it may, at perhaps no very distant period, be devoted to its accomplishment. A recent communication from him to the Astronomical Society expresses satisfaction with the mounting of his instrument, and after many trials its great speculum has at last come forth nearly perfect from his laboratory.

Of all the phenomena of the heavens there are none which excite more general interest than comets,—those vagrant strangers, the gipsies as they have been termed of our solar system, which often come we know not whence, and at periods when we least expect them. Now, though the larger and brighter comets naturally excite most general public interest, and are really valuable to astronomers, as exhibiting appearances which tend to throw light on the internal structure of these bodies, and the nature of the forces which must be in operation to produce the extraordinary phenomena observed, yet some of the smaller telescopic comets are, perhaps, more interesting in a physical point of view. Thus the six periodical comets, the orbits of which have been determined with tolerable accuracy, and which return at stated intervals, are extremely useful, as being likely to disclose facts of which but for them we should possibly have ever remained ignorant. Thus, for example, when the comet of Encke, which performs its revolution in a period of a little more than three years, was observed at each return, it disclosed the important and unexpected fact, that its motion was continually accelerated. At each successive approach to the sun it arrives at its perihelion sooner and sooner; and there is no way of accounting for this so satisfactory as that of supposing that the space in which the planetary and cometary motions are performed, is everywhere pervaded by a very rarefied atmosphere, or ether, so thin as to exercise no perceptible effect on the movements of massive solid bodies like the planets, but substantial enough to exert a very important influence on more attenuated substances moving with great velocity. The effect of the resistance of the ether is to retard the tangential motion, and allow the attractive force of gravity to draw the body nearer to the sun, by which the dimensions of the orbit are continually contracted, and the velocity in it augmented. The final result will be, that after the lapse of ages this comet will fall into the sun;—this body, a mere hazy cloud, continually flickering as it were like a celestial moth round the great luminary, is at some distant period destined to be mercilessly consumed. Now the discovery of this ether is deeply interesting as bearing on other important physical questions, such as the undulatory theory of light; and the probability of the future absorption of comets by the sun is important, as connected with a very interesting speculation by Prof. William Thomson, who has suggested that the heat and light of the sun may be from time to time replenished by the falling in and absorption of countless meteors which circulate round it; and here we have a cause revealed which may accelerate or produce such an event.

In the progress of science it often happens that a particular class of observations, all at once, and owing to some peculiar circumstance, attracts very general attention, and becomes deeply interesting. This has been the case within the last few years, in reference to observations of the sun's disc, which were at one time made by very few individuals, and were indeed very much neglected both by professional and amateur astronomers. During this season of comparative neglect, there were not, however, wanting some enthusiastic individuals, who were in silence and seclusion obtaining data of great importance.

On the 1st September last, at 11h. 18m. a.m., a distinguished astronomer, Mr. Carrington, had directed his telescope to the sun, and was engaged in observing its spots, when suddenly two intensely luminous bodies burst into view on its surface. They moved side by side through a space of about 35,000 miles, first increasing in brightness, then fading away; in five minutes they had vanished. They did not alter the shape of a group of large black spots which lay directly in their paths. Momentary as this remarkable phenomenon was, it was fortunately witnessed and confirmed as to one of the bright lights by another observer, Mr. Hodgson, at Highgate, who, by a happy coincidence, had also his telescope directed to the great luminary at the same instant. It may be, therefore, that these two gentlemen have actually witnessed the process of feeding the sun by the fall of meteoric matter; but however this may be, it is a remarkable circumstance, that the observations at Kew show that on the very day, and at the very hour and minute of this unexpected and curious phenomenon, a moderate but marked magnetic disturbance took place; and a storm or great disturbance of the magnetic elements occurred four hours after midnight, extending to the southern hemisphere. Thus is exhibited a seeming connection between magnetic phenomena and certain actions taking

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place on the sun's disc,—a connection which the observations of Schwabe, compared with the magnetical records of our Colonial Observatories, had already rendered nearly certain. The remarkable results derived from the comparison of the magnetical observations of Captain Maguire on the shores of the Polar Sea, with the contemporaneous records of these Observatories, have been described by me on a former occasion. The delay of the government in re-establishing the Colonial Observatories has hitherto retarded that further development of the magnetic laws which would doubtless have resulted from the prosecution of such researches.

We may derive an important lesson from the facts above alluded to. Here are striking instances in which independent observations of natural phenomena have been strangely and quite unexpectedly connected together; this tends powerfully to prove, if proof were necessary, that if we are really ever to attain to a satisfactory knowledge of Nature's laws, it must be accomplished by an assiduous watching of all her phenomena, in every department into which Natural Science is divided. Experience shows that such observations, if made with all those precautions which long practice combined with natural acuteness teaches, often lead to discoveries which cannot be at all foreseen by the observers, though many years may elapse before the whole harvest is reaped. . . . . .

Many instances could be adduced of an insufficient appreciation of certain objects of scientific research. Large sums are expended on matters connected with science, but this is done on no certain and uniform system; and there is no proper security that those who are most competent to give good advice on such questions should be the actual persons consulted. It was partly with the hope of remedying these defects, and of generally improving the position of science in this country in its relation to the government, that the Parliamentary Committee of this Association was established. Many whom I am now addressing are aware of the steps adopted by the Parliamentary Committee, and subsequently by the Committee of Recommendations of this Association, for the purpose of collecting the opinions of the cultivators of Science on the question, Whether any measures could be adopted by government or parliament that would improve our position? The question was afterwards discussed by the Council of the Royal Society, who in 1857 agreed upon twelve resolutions in reply thereto. These resolutions recommend among other things, that government grants in aid of local funds should be applied towards the teaching of science in schools, the formation of provincial museums and libraries, and the delivery of lectures by competent persons, accompanied by examinations; and finally, that some existing scientific body, or some board to be created for the purpose, should be formally recognised, which might advise the government on all matters connected with science, and especially on the prosecution, reduction, and publication of scientific researches, and the amount of parliamentary or other grants in aid thereof; also on the general principles to be adopted in reference to public scientific appointments, and on the measures necessary for a more general diffusion of a knowledge of physical science among the nation at large; and which might also be consulted by the government on the grants of pensions to the cultivators of science. I was requested to transmit these resolutions to Lord Palmerston, and also to the Parliamentary Committee of this Association. Since that period these resolutions have been discussed by that committee; but partly because some of its most influential members have expressed grave doubts as to the expediency of urging their adoption at all, and partly for want of a favourable opportunity for bringing them forward, nothing further has yet been done. If it be true, as some of our friends imagine, that the recognition of such a body as has been above described, however useful it might prove if the public were disposed to put confidence in its suggestions, would only augment that feeling of jealousy which is disposed to view every application for aid to scientific research in the light of a request for some personal boon to be bestowed on some favoured individual, then indeed its institution would not be expedient. I wish that persons who entertain such views would pay some attention to the working of the Government Grant Committee of the Royal Society, a body composed of forty-two persons selected from among the most eminent cultivators of science, and which is intrusted with the distribution of an annual sum of £1000, placed by parliament at the disposal of the Royal Society in aid of scientific inquiries. One of the rules of that committee is, that no sum whatever shall be given to defray the merely personal expenses of the experimenters; all is spent on materials and the construction or purchase of instruments, except in a very few and rare instances in which travelling expenses form the essential feature of the outlay. A list of the objects to which the grants are devoted has been published by parliament: among them are interesting investigations into the laws of heat; the strength of materials used in building, the best form of boilers, from the bursting of which so many fatal accidents are continually occurring; the electric conductivity of metals, so important for telegraphic communication: and into many other questions in the solution of which the public generally have the deepest interest. These grants have provided also for the construction of better and standard meteorological and magnetical instruments; for the execution of valuable drawings of scarce fossils and zoological specimens; for the reduction and publication of astronomical observations by some of our most highly-esteemed astronomers; and for physiological researches which have an important bearing on our knowledge of the human frame. Time indeed would fail me, were I to attempt to describe all the good done, and perhaps evil prevented, by the distribution of these grants. To quote from a letter addressed to the Secretary of the Treasury, at a time when the grant was temporarily withheld: "by the aid of this contribution, the government has, in fact, obtained for the advancement of science and the national character the personal and gratuitous services of men of first-rate eminence, which, without this comparatively small assistance, would not have been so applied." The recognition of such a board as has been sketched out by the Council of the Royal Society may not lead to a greater expenditure of public money; indeed, it is much more likely to curtail it; as some who now apply for aid through the interest of persons having influence with those in authority, who are generally but ill-informed on the subject-matter of the application, would hesitate long before they made a similar request to those who are thoroughly conversant with it; and it is on this account that comparatively few of the applications to the Government Grant Committee are rejected; and as every grant passed by the proposed board would afterwards receive the jealous scrutiny of parliament, whose sanction must of course be obtained, I am disposed to think that were I to support the establishment of such a scientific council, or the formal recognition by the State of some existing scientific body in that capacity, I should be advocating that which would prove a valuable addition to the institutions of my country. . . . . .

Having detailed some of the valuable services of our amateur astronomers, I will mention the professional contributors to the data of that noble science. Most valuable Star Catalogues have resulted from the labours of our public Observatories, and from Greenwich in particular. There are also two Observatories which have as it were a *quasi* public character, viz. the Radcliffe Observatory and that of Armagh, which have contributed much to this department of astronomy. Your former President, Dr. Robinson, of Armagh, has lately presented to the astronomical world a Catalogue of the places of more than 5000 stars, and in so doing has conferred a most important benefit on his favourite science. Our gratitude is due to our great national institution at Greenwich, for the manner in which it has consistently discharged the task imposed upon it by its founder and those who inaugurated its first proceedings. The duty assigned to it was "to rectify the tables of the motions of the heavens and the places of the fixed stars, in order to find out the so-much-desired longitude at sea, for perfecting the art of navigation;" and gloriously has it executed its task. For two centuries it has been at work, endeavouring to give to the determinations of the places of the principal fixed stars, and of the heavenly bodies of our own solar system, and more especially of the moon, the utmost degree of precision; and during the same period the master minds of Europe have been engaged in perfecting the analytical theory, by which the many and most perplexing inequalities of the moon's motion must be accounted for and represented before tables can be constructed giving the place of our satellite with that accuracy that the modern state of science demands.

The very important task of calculating such tables has just been finished. Our able director of the National Observatory, Mr. Airy, had caused all the observations of the moon made at Greenwich from 1750 to 1830 to be reduced upon one uniform system, employing constants derived from the best modern researches; and a distinguished Danish professor, who had been for some time engaged in calculating new Tables of the Moon, availed himself of the data so furnished. Prof. Hansen happily

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brought to his task all the accomplishments of a practised observer, and of one of the most able analysts of modern times, combined with the most determined industry and perseverance. In the completion of it he was liberally assisted by our government, at the time when an unhappy war had deprived the Danish government of the means of further aiding their professor. Prof. Hansen's Tables are now finished and published: they agree admirably with the Greenwich Observations with which they have been compared, and the mode of their execution has been approved by those competent to express an opinion on such a subject. They have been rewarded also with the Gold Medal of the Astronomical Society. In paying this tribute to the merit of Prof. Hansen, I must not be understood as wishing to ignore, far less to depreciate, that of three very eminent geometers, Plana, Lubbock, and Pontécoulant, who have devoted years of anxious and perhaps ill-requited labour, to the investigation of the lunar inequalities, but who have never yet embodied the results in the only form useful to navigation, that of tables.

A curious controversy has lately arisen on the subject of the acceleration of the moon's motion, which is now exciting great interest among mathematicians and physical astronomers. Prof. Adams and M. Delaunay take one view of the question; MM. Plana, Pontécoulant, and Hansen, the other. Mr. Airy, Mr. Main, the President of the Astronomical Society, and Sir John Lubbock support the conclusions at which Prof. Adams has arrived. The question in dispute is strictly mathematical; and it is a very remarkable fact in the history of astronomy, that such great names should be ranged on opposite sides, seeing that the point involved is really no other than whether certain analytical operations have been conducted on right principles; and it is a proof therefore, if any were wanting, of the extraordinary complexity and difficulty of these transcendental inquiries The controversy is of the following nature:—The moon's motion round the earth, which would be otherwise uniform, is disturbed by the sun's attraction; any cause therefore which affects the amount of that attraction affects also the moon's motion: now, as the eccentricity of the earth's orbit is gradually decreasing, the average distance of the sun is slightly increasing every year, and his disturbing force becomes less; hence the moon is brought nearer the earth, but at the rate of less than one inch yearly; her gravitation towards the earth is greater, and her motion proportionably accelerated. It is on the secular acceleration of the moon's mean motion, arising from this minute yearly approach, that the dispute has arisen; so infinitesimally small are the quantities within the reach of modern analysis. Mr. Adams asserts that his predecessors have improperly omitted the consideration of the effect produced by the action of that part of the sun's disturbing force which acts in the direction of a tangent to the moon's orbit, and which increases the velocity; his opponents deny that it is necessary to take this into account at all. Had not M. Delaunay, an able French analyst, by a perfectly independent process, confirmed the results of Prof. Adams, we should have had the English and continental astronomers waging war on an algebraical question. On the other hand, however, the computations of the ancient lunar eclipses support the views of the continent; but if Mr. Adams's mathematics are correct, this only shows that there must be other causes in operation, as yet undiscovered, which influence the result; and it is not at all unlikely that this most curious and interesting controversy will eventually lead to some important discovery in physical astronomy.

You are aware that at the suggestion of Sir John Herschel an instrument was constructed for the Kew Observatory, to which the name Photoheliograph has been given, because it is adapted solely to the purpose of obtaining photographic representations of the appearances of the sun's disc. Many difficulties have been encountered in the use of this instrument; but by the zealous exertions of the late Mr. Welsh, Mr. Beckley, and Mr. De la Rue, they have been overcome. It is to the last-named gentleman, so distinguished for his successful prosecution of celestial photography, that the Royal Society have entrusted a grant of money to enable him to transport the Photoheliograph to Spain, to observe the total eclipse of the sun which is now approaching, and great interest will attach to records of the phenomena of the eclipse thus obtained.

In *Chemistry* I am informed that great activity has been displayed, especially in the organic department of the science. For several years past processes of substitution (or displacement of one element or organic group by another element or group more or less analogous) have been the main agents employed in investigation, and the results to which they have led have been truly wonderful; enabling the chemist to group together several compounds of comparatively simple constitution into others much more complex, and thus to imitate up to a certain point, the phenomena which take place within the growing plant or animal. It is not indeed to be anticipated that the chemist should ever be able to produce by the operations of the laboratory the arrangement of the elements in the forms of the vegetable cell or the animal fibre; but he may hope to succeed in preparing some of the complex results of secretion or of chemical changes produced within the living organism,—changes which furnish definite crystallisable compounds, such as the formiates and the acetates, and which he has actually obtained by operations independent of the plant or the animal.

Hofmann, in pursuing the chemical investigation of the remarkable compound he has termed Triethylphosphine, has obtained some very singular compound ammonias. Triethylphosphine is a body which takes fire spontaneously when its vapour is mixed with oxygen at a temperature a little above that of the body. It may be regarded as ammonia in which an atom of phosphorus has taken the place of nitrogen, and in which the place of each of the three atoms of hydrogen in ammonia is supplied by ethyl, the peculiar hydro-carbon of ordinary alcohol. From this singular base Hofmann has succeeded in procuring other coupled bases, which though they do not correspond to any of the natural alkalies of the vegetable kingdom, such as morphia, quinia, or strychnia, yet throw some light upon the mode in which complex bodies more or less resembling them have been formed.

The power which nitrogen possesses of forming a connecting link between the group of substances of comparatively simple constitution, has been remarkably exemplified by the discovery of a new class of amide acids by Griess, in which he has pointed out a new method which admits of very general application, of producing complex bodies related to the group of acids in some measure analogous to the poly-ammonias of Hofmann.

Turning to the practical applications of chemistry, we may refer to the beautiful dyes now extracted from aniline, an organic base formerly obtained as a chemical curiosity from the products of the distillation of coal-tar, but now manufactured by the hundred-weight, in consequence of the extensive demand for the beautiful colours known as Mauve, Magenta, and Solferino, which are prepared by the action of oxidising agents, such as bichromate of potash, corrosive sublimate, and iodide of mercury upon analine.

Nor has the inorganic department of chemistry been deprived of its due share of important advances. Schönbein has continued his investigations upon ozone, and has added many new facts to our knowledge of this interesting substance; and Andrews and Tait by their elaborate investigations have shown that ozone, whether admitted to be an allotropic modification of oxygen or not, is certainly much more dense than oxygen in its ordinary condition.

In *Metallurgy* we may point to the investigations of Deville upon the platinum group of metals, which are especially worthy of remark on account of the practical manner in which he has turned to account the resources of the oxy-hydrogen blow-pipe, as an agent which must soon be very generally adopted for the finer description of metallurgic operations at high temperatures. By using lime as the material of his crucibles, and as the support for the metals upon which he is operating, several very important practical advantages have been obtained. The material is sufficiently infusible to resist the intense heat employed; it is a sufficiently bad conductor of heat to economise very perfectly the high temperature which is generated; and it may be had sufficiently free from foreign admixture to prevent it from contaminating the metals upon which the operator is employed.

The bearing of some recent *Geological* discoveries on the great question of the high antiquity of man was brought before your notice at your last meeting at Aberdeen, by Sir Charles Lyell, in his opening address to the Geological Section. Since that time many French and English naturalists have visited the valley of the Somme in Picardy, and confirmed the opinion originally published by M. Boucher de Perthes in 1847, and afterwards confirmed by Mr. Prestwich, Sir C. Lyell, and other geologists, from personal examination of that region. It appears that the position of the rude flint implements, which are unequivocally of human workmanship, is such at Abbeville and Amiens, as to show that they are as ancient as a great mass of gravel which

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fills the lower parts of the valley between those two cities, extending above and below them. This gravel is an ancient fluviatile alluvium by no means confined to the lowest depressions (where extensive and deep peat-mosses now exist), but is sometimes also seen covering the slopes of the boundary hills of chalk at elevations of 80 or 100 feet above the level of the Somme. Changes therefore in the physical geography of the country, comprising both the filling up with sediment and drift, and the partial re-excavation of the valley, have happened since old river beds were, at some former period, the receptacles of the worked flints. The number of these last, already computed at above 1400, in an area of fourteen miles in length and half a mile in breadth, has afforded to a succession of visitors abundant opportunities of verifying the true geological position of the implements.

The old alluvium, whether at higher or lower levels, consists not only of the coarse gravel with worked flints above mentioned, but also of super-imposed beds of sand and loam, in which are many freshwater and land shells, for the most part entire, and of species now living in the same part of France. With the shells are found bones of the mammoth and an extinct rhinoceros, *R. tichorhinus*, and an extinct species of deer, and fossil remains of the horse, ox, and other animals. These are met with in the overlying beds, and sometimes also in the gravel where the implements occur. At Menchecourt, in the suburbs of Abbeville, a nearly entire skeleton of the Siberian rhinoceros is said to have been taken out about forty years ago, a fact affording an answer to a question often raised as to whether the bones of the extinct mammalia could have been washed out of an older alluvium into a newer one, and so redeposited and mingled with the relics of human workmanship. Far-fetched as was this hypothesis, I am informed that it would not, if granted, have seriously shaken the proof of the high antiquity of the human productions, for that proof is independent of organic evidence or fossil remains, and is based on physical data. As was stated to us last year by Sir C. Lyell, we should still have to allow time for great denudation of the chalk, and the removal from place to place, and the spreading out over the length and breadth of a large valley, of heaps of chalk flints in beds from 10 to 15 feet in thickness, covered by loams and sands of equal thickness, these last often tranquilly deposited; all of which operations would require the supposition of a great lapse of time.

That the mammalia fauna preserved under such circumstances should be found to diverge from the type now established in the same region, is consistent with experience; but the fact of a foreign and extinct fauna was not needed to indicate the great age of the gravel containing the worked flints.

Another independent proof of the age of the same gravel and its associated fossiliferous loam is derived from the large deposits of peat above alluded to in the valley of the Somme, which contain not only monuments of the Roman, but also those of an older stone period, usually called Celtic. Bones also of the bear, of the species still inhabiting the Pyrenees, and of the beaver, and many large stumps of trees not yet well examined by botanists, are found in the same peat, the oldest portion of which belongs to times far beyond those of tradition. Yet distinguished geologists are of opinion that the growth of all the vegetable matter, and even the original scooping out of the hollows containing it, are events long posterior in date to the gravel with flint implements—nay, posterior even to the formation of the uppermost of the layers of loam with freshwater shells overlying the gravel.

The exploration of caverns both in the British isles and other parts of Europe has in the last few years been prosecuted with renewed ardour and success, although the theoretical explanation of many of the phenomena brought to light seems as yet to baffle the skill of the ablest geologists. Dr. Falconer has given us an account of the remains of several hundred hippopotami obtained from one cavern in Palermo, in a locality where there is now no running water. The same palæontologist, aided by Col. Wood, of Glamorganshire, has recently extracted from a single cave in the Gower peninsula of South Wales, a vast quantity of the antlers of a reindeer (perhaps of two species of reindeer), both allied to the living one. These fossils are most of them shed horns, and there have been already no less than 1100 of them dug out of the mud filling one cave.

In the cave of Brixham, in Devonshire, and in another near Palermo, in Sicily, flint implements were observed by Dr. Falconer, associated in such a manner with the bones of extinct mammalia, as to lead him to infer that man must have co-existed with several lost species of quadrupeds; and M. de Vibraye has also this spring called attention to analogous conclusions, at which he has arrived by studying the position of a human jaw with teeth, accompanied by the remains of a mammoth, under the stalagmite of the Grotto d'Arcis, near Troyes, in France. . . . . .

And now, in conclusion, I may perhaps be permitted to express the hope that the examples I have given of some of the researches and discoveries which occupy the attention of the cultivators of science may have tended to illustrate the sublime nature, engrossing interest and, paramount utility of such pursuits, from which their beneficial influence in promoting the intellectual progress and the happiness and well-being of mankind may well be inferred. But let us assume that to any of the classical writers of antiquity, sacred or profane, a sudden revelation had been made of all the wonders involved in creation accessible to man; that to them had been disclosed not only what we know now, but what we are to know hereafter in some future age of improved knowledge;—would they not have delighted to celebrate the marvels of the Creator's power? They would have described the secret forces by which the wandering orbs of light are retained in their destined paths; the boundless extent of the celestial spaces in which worlds on worlds are heaped; the wonderful mechanism by which light and heat are conveyed through distances which to mortal minds seem quite unfathomable; the mysterious agency of electricity, destined at one time to awaken men's minds to an awful sense of a present Providence, but in after-times to become a patient minister of man's will, and convey his thoughts with the speed of light across the inhabited globe; the beauties and prodigies of contrivance which the animal and vegetable world display, from mankind downwards to the lowest zoophyte,—from the stately oak of the primeval forest to the humblest plant which the microscope unfolds to view; the history of every stone on the mountain brow, of every gay-coloured insect which flutters in the sunbeam;—all would have been described, and all which the discoveries of our more fortunate posterity will in due time disclose, and in language such as none but they could command. It is reserved for future ages to sing such a glorious hymn to the Creator's praise. But is there not enough now seen and heard to make indifference to the wonders around us a deep reproach, nay, almost a crime? If we have neither leisure nor inclination to track the course of the planet and comet through boundless space; to follow the wanderings of the subtle fluid in the galvanic coil or the nicely-poised magnet; to read the world's history written on her ancient rocks, the sepulchres of stony relics of ages long gone past; to analyse with curious eye the wonderful combinations of the primitive elements and the secret mysteries of form and being in animal and plant; discovering everywhere connecting links, and startling analogies and proofs of adaptation of means to ends,—all tending to charm the senses, to teach to reclaim a being who seems but a creeping worm in the presence of this great creation;—what, I repeat, if we will not or cannot do these things, or any of these things, is that any reason why these speaking marvels should be to us almost as though they were not? Marvels indeed they are; but they are also mysteries, the unravelling of some of which tasks to the utmost the highest order of human intelligence. Let us ever apply ourselves seriously to the task, feeling assured that the more we thus exercise, and by exercising improve, our intellectual faculties, the more worthy shall we be—the better shall we be fitted, to come nearer to our God.

Proceedings of Sections.

On the Mechanical Effect of combining Girders and Suspension Chains, and the application of the system to practical purposes.

By Peter W. Barlow, F.R.S.

At the meeting of 1857 a paper was read by me on this subject, my attention having been directed to it from being required to investigate (as engineer in chief to the Londonderry and Enniskillen and Coleraine railways) the best mode of connecting the railways across the river Foyle, in combination with a road bridge. The depth and bad bottom of the river led me to recommend a suspension bridge combined with a girder; and in order to investigate the strain and the amount of girder power required to cure the oscillation and wave, the model was made which I now submit to the meeting.

The design, when submitted to the commissioners of the road bridge, was approved by Sir William Cubitt, then their consult-

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ing engineer; but some doubts having been suggested as to the fitness of suspension bridges for railway traffic, the question was submitted to Mr. Hawkshaw, who recommended the girder bridge now in course of erection by the road commissioners.

It is no doubt the safest course for an engineer to recommend what has been done before, and to avoid experiments; but this, it is submitted, does not render it less desirable that the subject I now bring before you should be understood as a mechanical question, as it is admitted by the strongest opponents of suspension bridges that they are practicable and advantageous when large spans cannot be avoided; and we have as a fact the Niagara Bridge, of 822 feet span, constructed principally of timber, in a situation exposed to severe hurricanes, which has carried over for six years the heavy goods and passenger railway traffic of the New York Central and Great Western of Canada railways.

It is not however in cases where large spans are indispensable that this principle of construction is alone advisable. In the case of the Londonderry Bridge, it is not impracticable to construct piers in the river, but they are attended with serious risk and cost, and interruption to the navigation, which in the opinion of Sir W. Cubitt might have been avoided, and a superior engineering work made at less cost.

The same thing occurs in London. The Hungerford Suspension Bridge has become the site of a railway extension, and it is at once assumed that for railway purposes it is inadmissable; and this bridge, so ornamental to the river, is to be superseded by a girder bridge, with numerous piers in the river,—in my view, because the mechanical effect of a combination of chains and girders is not sufficiently understood; and for this reason I desire to press the investigation of the subject. But referring again to the Niagara Bridge, which is 822 feet in span, and of which the girder portion is of timber,—if this bridge will stand heavy railway traffic, can it be doubted that a bridge entirely of iron of the best quality, or the improved material, puddled steel, can with safety be constructed of much larger spans.

But it is not only to avoid the difficulties of rivers that a successful suspension girder bridge would be useful, for in many cases valuable property may be saved, and even the difficulties of dealing with the crowded traffic of the streets of London very much diminished. A suspension girder bridge of spans of 2000 feet is perfectly practicable constructed with superior metal, as my experiments will prove, but 1000 feet is sufficient to meet the difficulties of the case; and lines of railway can thus be easily carried across a crowded city, at less cost and with less destruction of property than by underground railways, or any other means that has hitherto been suggested. I shall speak subsequently more in detail of the cost and practicability of such lines of communication, but it is necessary now to say a few words to justify my claiming the attention of the Association to the subject.

The principal cost of a structure consisting of a series of openings will be the suspension wires or chains and the towers. The amount of girder power to cure the wave and oscillation will not be found, as my experiments will show, to be a serious addition to the cost; and the item in ordinary suspension bridges which forms the largest proportion of the cost, the anchorage, will here be divided over numerous openings. With reference to the chains or wires, the most ready estimates will be deduced by reference to any existing structure, and I select the Niagara Bridge, as the only one testedby railway traffic. Here we have a section of 242 inches of wire, with a weight of 310 tons, and a span of 822 feet. In a series of spans, the suspension chains, irrespective of the towers, would form fully half the weight of metal in the structure; and assuming a price of £40 per ton, we have £12,400 per opening as the cost, assuming that for the purposes of omnibus traffic we require an amount of strength which has been found sufficient in a locomotive railway of heavy traffic, combined at the same time with a separate carriage road communication.

The rule for ascertaining the sufficiency of railway bridges adopted by the officers of the Board of Trade is, to estimate the strain produced by the greatest weight which by possibility could come on the bridge throughout every part of the structure, which should not exceed one-fifth of the ultimate strength of the metal.

The strength necessary therefore depends in a great measure on the mode of traction adopted, and it is therefore a very important question in this case to consider whether the locomotive steam engine is the best mode of traction where the traffic will be entirely of an omnibus character, requiring trains as frequently as every four or five minutes to give efficient accommodation and relief, but of the lightest character. Parsey's air engine and the atmospheric system may be well adapted to the purposes of such traffic; although they may be justly condemned as inapplicable to ordinary railway traffic, they possess advantages where the traction power required is not such as to exhaust the reservoir of power too rapidly, which will not be the case in the present application, partly because the trains will be very light, and partly because at every pier or tower small stationary engines will be used, for the purpose of raising the passengers from the surface of the ground to the platform of the railway, which would furnish a supply of compressed air for the renewal of the reservoir of the air locomotive.

Without entering further at present into the question of the practicability of this suggestion, or whether the atmospheric or other stationary system may be used, I will assume that such a system of traction is adopted, or that a locomotive of half the weight only of ordinary locomotives is required, and therefore the ultimate weight which might arise on such a bridge would not exceed one-half of what might occur on a railway bridge assuming the extreme case, as to be loaded from end to end with locomotives. It is generally believed that a bridge for ordinary road traffic does not require to be made of the same strength as an ordinary railway bridge; but this I believe to be an error. A railway bridge covered from end to end with locomotives is a possible strain to which it may be subjected, but in a large span it is a less possible or probable contingency than that of a road bridge being densely packed with passengers or soldiers, by which a greater actual weight would arise in bridges 30 feet wide, with a greater amount of vibration.

It is true that many failures have occurred in suspension bridges, which have much shaken public confidence in them, but it is only necessary to examine the causes of their failure, to see that they were the certain results of the defect of construction; and when these cases are examined they become evidence of the advantages of the principle, not of its defects. If road like railway bridges had been constructed under the supervision of the Board of Trade, not a single failure would have occurred; but as these bridges have been constructed with from one-sixth to one-eighth the section of iron that the Board of Trade would require, without any means of correcting the wave and vibration, it is not surprising that they have failed, but rather that they have existed so long, and that some of them now exist.

The public may rest satisfied that any bridge which has obtained the approval of the Board of Trade is not only sufficiently strong, but much in excess of the necessary strength; and they can as safely reside under them as under the roof of a house; and it is in accordance with these rules that my estimate is formed.

The section of metal in the suspension chains or wires required for a double line of railway, with a span and depth equal to the Niagara Bridge, with girders constructed of good iron, to comply with the Board of Trade rule, would be more than 240 inches; and I propose to adopt this section, that is to say, to give the same strength to my structure for light railway passenger traffic as has been given to the Niagara Bridge, which has a road communication in addition to a heavy railway traffic, in a situation exposed to the most severe hurricanes. We thus arrive approximately at the main cost of the structure, viz., the supporting chains, which will contain 2000 tons per mile, which at £40 per ton will be £80,000.

We have next to consider the cost of the towers or piers, which I propose to construct of wrought or cast iron; and we have at the Crystal Palace an example of a similar structure, from which the cost may be deduced. These towers are 220 feet in height, and support 1800 tons of water at the top. The towers required for such a bridge will not have so much weight to support, and the height will not exceed 150 feet; and allowing the same section of metal and strength, the cost will not exceed £10,000 each tower.

The next large item is the cost of the girders and the platform necessary to prevent the undulation or wave,—a necessary addition to every suspension bridge, but one which has hitherto been generally neglected; and thus has arisen the want of confidence in a mode of construction which admits of numerous applications of great public importance.

The investigation of this part of the subject is the immediate object of this paper, as the strains and necessary weight of metal in the main suspenders has been long investigated and fully established; but for the purposes of the approximate estimate I

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shall only here state that a weight of metal equal to chains will be found to be sufficient at a cost of £60,000; and thus a total cost, allowing for land and other contingencies, of £300,000 per mile would carry such a structure through the densest part of London,—a sum small compared with the object to be attained, and which would probably be much reduced on further investigation, as it accomplishes the object of railway communication with less destruction of property than a tunnel, which will be unavoidably most unpleasant for passengers, and more objectionable for the application of steam and locomotive power than a viaduct, where, if Parsey's system does not admit of practicable adoption, light locomotives may without difficulty be used. I am, however, dwelling more on this part of the subject than the title of my paper justifies, my object being merely to show, that if a system of larger spans can with safety be established for railway purposes, that there are so many instances of useful application to the public, that the subject is deserving of serious investigation.

General Remarks upon the Construction of Bridges of Large Span.—Bridges may be divided into three classes—

1st. The Arch, a structure in which the supporting material is subjected to compression alone, but which contains no rigidity in itself.

2nd. The Suspension Bridge, in which the supporting material is subjected to extension alone, which also contains no rigidity in itself; and,

3rd. The Girder, in which the material is subjected to both extension and compression, of which there are two varieties; one, which is subjected to diagonal strains, as the lattice, Warren, and tubular girders; and a second in which all the strains are confined to the upper and lower webs, as in the bow and string; and Mr. Brunel's new girder, which is a combination of an arch and a suspension chain, each doing half the supporting duty.

The second variety is the most simple form, but has no more rigidity in itself than an ordinary arch or suspension bridge.

Of these three systems the girder necessarily requires, from combining compressive and extensive resistances, a much larger amount of metal than either of the other systems, which will be rendered evident by a simple investigation, and by a reference to existing structures.

In an ordinary arch the compressive force is resisted by the abutments, which in no way add weight or strain to the metal; but, if the arch is converted into a girder, it can only be done by adding a tie-bar, the arch having then to support its own tie or substitute for an abutment in addition to its own weight.

In a suspension bridge the tensile force is resisted by back chains; and if these are taken away to make it a girder, a compression-tube or bar has to be used as a substitute for them (as in the Chepstow Bridge), which tube becomes in large spans, with its supports, by far the largest portion of the structure, and destroys the bridge by its own weight, the weight of metal being fully doubled to produce equal strength, and quadrupled to produce equal stiffness, if loaded equally all over.

It is thus evident, that if you convert a girder into an arch or suspension chain of the same depth, you at once dispense with half the supporting material, from duty being transferred to the abutments or anchorage, and being double the stiffness. Thus theoretically an arch will produce the same saving as a suspension chain, but it is not so in practice, because there is much greater difficulty in dealing with compression than with extension. In the latter case the strength is correctly measured by the section of the metal; but where you have compressive strains to deal with wrought-iron is liable to buckling, and you thus cease to have any true measure of its strength and power of resistance, a difficulty which arises not only in large iron arches, but occurs also in deep girders, and thus limits the extent of their application.

Mr. E. Clarke, who published an account of the Britannia tube, concludes his investigation of the subject by arriving at a similar conclusion, in which he no doubt also expresses the views of Robert Stephenson. In speaking of the limits to which tubes similar to the Britannia would be carried out, he says—

"If the dimensions of the section remain constant and the length only were increased, the tube would break with its own weight when it became about 850 feet long.

But if the dimensions of the section were also increased, so that the tube retained the same proportions, becoming then a *similar* tube to what it is at present, it would break with its own weight when it became about 1570 feet long. The depth of the tube would in this case be 100 feet, the breadth 48 feet, and the weight 62,000 tons.

Other curious properties of similar tubes may be determined from the preceding reasoning; but in practice these theoretical limits cannot be approached. The impossibility of construction, the rapid increase in the weight of the requisite pillars for any great extension of depth, the necessary additions for preserving the general form of a large structure, considered merely as an edifice, independent of its action as a beam, and the great crushing strain to which the bearings would be subjected, are all elements increasing in a high ratio with the dimensions, and rendering impossible on similar principles any structure of much greater magnitude than the Britannia Bridge. This will be evident if we call to mind that in that tube twenty-one per cent. of the whole weight of the sides is already consumed in stiffening them; and not only would the weight of a larger structure increase as the cube of its length, but it would also require a much larger percentage of stiffening plates in the sides, for as the pillars increase in height the weight increases as the cube of the length, while the strength is only as the square.

In this respect the ordinary suspension-bridge possesses considerable advantage over other structures, for the strain being wholly tensile, the laws of pillars do not come into operation, and such bridges may be safely constructed of magnificent dimensions with little material.

These advantages however at once disappear when the horizontal strain is resisted by a pillar forming a portion of the structure itself, as in the case of the Chepstow Bridge; and the limits of such a system are nearly similar to those of a tube, the weight per foot run increasing nearly as the square of the length, and therefore the weight of the whole as the cube.

The magnitude of the arch is limited, like that of the beam, by the danger of distortion, its stability being dependent on the laws of pillars; the thrust on the abutments becomes moreover a formidable difficulty in arches of great magnitude."

These observations, in which I fully concur, are very important. It must be admitted on all hands, that a structure whose direct strength depends on the resistance to the extension of iron is safer and of greater strength than one which depends upon its compressive resistance. First, because the extensibility obeys known laws, and metal is superior in tensile strength; secondly, for the reason above described, that you avoid the necessity of loading your bridge with material to produce compressive resistance; and thirdly, because the deflection varies nearly as the square of the depth, and you can have increased depth in a suspension bridge with little additional material and cost. A comparison of existing structures will at once prove this; and as an example I will mention that the two tubes of the Britannia Bridge contain 2500 tons of supporting material in a span of 460 feet, while the Niagara Bridge, of equal strength and of 822 feet span, contains only 310 tons.

In the face of such undeniable facts, it is surprising that a system of parallel girders for large spans has been adopted, the safety of which as regards direct strength is not so certain, because you depend on compressive resistance, which may suddenly fail from buckling, as you cannot estimate where it will occur from experiments on a model; and you are therefore only certain of the strength of your structure as far as you actually test it, and have not that margin of the excess of certain strength to allow for deterioration which it is desirable to obtain.

As these advantages of suspension structures must be obvious, the question at once suggests itself, why have they been abandoned for railway purposes, where safety is so important? the only answer to which is the supposed impracticability of curing the oscillation and the wave produced by a passing load; and it is to the investigation of this important subject that my experiments and observations are directed.

The first objection, that of the oscillation or swinging produced by a hurricane, is not a serious one, as the force of wind can only occasion mischief in combination with its action on the timber platform of the bridge, producing undulation and waves, and has been cured by Mr. Rendel by the addition of a girder parapet of wood. It could not occur in bridges with an iron platform, and stiffened by a girder of good iron, presenting comparatively little resistance to the wind; and I have therefore reduced my experiments alone to the cure of the wave. For the purpose of my experiments I had a model made which represented one opening of the intended Londonderry Bridge, $\frac{1}{35}$rd of the intended size, the length between the towers being 13½ feet, which it is submitted is of sufficient dimensions to deduce accurate results when large compressive strains are not the subject of investigation.

To illustrate the object of my experiments I will again explain that a suspension chain *per se* has no rigidity in itself,—a weight placed on any part will instantly distort the figure, and the platform will take the form of a wave; and thus the numerous bridges erected on this principle, without a means of correcting the distortion, are unfit for the purpose of traffic of any kind. The obvious correction for this undulation, which has been

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adopted by Mr. Rendel and Mr. Roeblin with success, is a girder attached to the platform of the bridge, so that the weight is distributed and the wave is diminished to such a degree as to be unobjectionable in practice; and the mechanical question for consideration is, the amount of wave which will arise with a girder of a given depth and section of iron. Previous calculations and experiments on girders enable an estimate to be made of the deflection of the girder of a given length with a given weight; and therefore the deflection of any girder intended to be attached to a chain can be calculated. It therefore occurred to me, that if the relation between the deflection of a girder attached to the chain and that of the same girder unattached, could be obtained, that we should be able to ascertain precisely what girder to allow to a chain so that a given load would produce a given amount of deflection. For this purpose I made a series of experiments upon girders of different kinds, attached and unattached to the chain; and the following are the results arrived at:—

I decided in order to magnify the wave, and make its amount more distinct, to have a girder made of angle-iron ⅛-inch thick, and a quarter the depth of the former girder, but simply suspended from and not attached to the chain.

The deflection of this girder without the chains, with a load of 42 lb. placed on the centre, was 1·2 inch.

The deflection of the wave with the chain attached, and 227 lb. distributed over the girder, when the weights were placed at ¼ from the high tower, were with

lb.	¼ from high tower. inch.	Centre. inch.	¼ from low tower. inch.
56	— ·10	— ·01	+ ·05
112	— ·20	— ·04	+ ·12
168	— ·28	— ·06	+ ·16

Experiment 2.—In this case the weights were placed at ¼ from the low tower:—

56	+ ·06	— ·01	— ·12
112	+ ·15	— ·05	— ·25
168	+ ·18	— ·07	— ·36

The deflections here averaged ·32 inch with 168 lb., equal to ·08 inch with 42 lb., or $\frac{1}{15}$ the deflection of the girder without the chain.

The deflection of the Londonderry girder, deduced from the mean results of the deflections of the Boyne Viaduct and Newark Bridge and the Britannia Tube was 33 inches, with 100 tons in the centre; $\frac{33}{15}$=2·20 inches, the deflection here indicated in the Londonderry Bridge with 100 tons placed at ¼ the length of the girder.

It was still obvious, from the deflection at the centre and little rise exhibited in the wave, that the stretching of the chain to bring the metal surfaces to bear still sensibly influenced the result; and I had another wooden girder made, consisting of a plank 7½ inches in width and ⅜-inch thick, in order to still more magnify the wave, and to diminish the error from the stretching of the chain.

The deflection without the chain attached was 1·48 inch with 10 lb.

Experiments with the Chain attached.—With 56 lb. placed at ¼ from the high tower on the girder which was previously quite unloaded, the deflections were, at

¼ from high tower. inch.	¼ from high tower. inch.	¼ from high tower. inch.	¼ from high tower. inch.	¼ from high tower. inch.	¼ from high tower. inch.	¼ from high tower. inch.
— ·31	— ·48	— ·32	— ·02	+ ·22	+ ·29	+ ·15

Experiment 2.—70 lb. being equally distributed over the girder, and 56 lb. at ¼ from high tower:

— ·28 — ·42 — ·25 + ·04 + ·23 + ·28 + ·20

Experiment 3.—150 lb. all over, weight in same place:

— ·20 — ·35 — ·20 + ·02 + ·20 + ·23 + ·14

Experiment 4.—193 lb. equally distributed, 56 lb. as before:

— ·18 — ·31 — ·17 + ·05 + ·18 + ·20 + ·14

The deflection here indicated, with the model loaded with a weight representing 96 tons on the bridge (which experiment was several times repeated) was ·31 with 56 lb. = ·055 with 10 lb., or $\frac{1}{26}$ of the deflection of the girder without the chain; $\frac{33}{26}$ = 1·27 is therefore the deflection of the wave indicated by the experiment of the Londonderry Bridge with a load of 100 tons at ¼ from the tower.

To obtain the comparative rigidity of the experimental girder: we have here,—as 206 lb. : 10 lb. : : 1 in. : ·0485, the deflection of a true model with 10 lb.; $\frac{1{\cdot}48}{{\cdot}0485}$ or $\frac{1}{30{\cdot}5}$ represents the rigidity of the experimental girder; $\frac{{\cdot}31}{30{\cdot}5} \times 33 = {\cdot}335$, the deflection by a weight on the bridge of $56 \times 33^2 = 27$ tons. 27 : 100 : : ·335 : 1·27, the deflection as previously calculated.

This result being so much at variance with the general view of the subject, although very nearly in accordance with my calculations, I determined to verify it by a smaller girder, 6 inches by ¾ thick, which would render the wave still more visible; the observations being made with great nicety.

The deflection at the centre when not attached to the chain was 2·375 inches with 8 lb. Girder attached to the chains, 193 lb. being equally distributed over it: the deflection, with the weight placed ¼ from the high tower, was

lb.	¼ from high tower. inch.	Centre. inch.	¼ from low tower. inch.
56	— ·64	+ ·13	+ ·53

Experiment 2.—With 56 lb. at the centre of the bridge the deflection was —·30.

The deflection of the wave here exhibited at ¼ of the length, with the bridge loaded to a weight equivalent to 100 tons on the actual bridge (which experiment was repeated several times with the same result), was 0·64 inch with 56 lb.; the deflection without the chains being 2·375 with 8 lb., or 25 times the amount.

In determining how far this result was effected by the resistance produced by the change of figure in the curve of the chain, I removed all the weights from the plank, and found the result as follows, with 56 lb. at ¼ from the high tower:—

¼ from high tower. inch.	Centre. inch.	¼ from low tower. inch.
— ·85	+ ·20	+ ·75

With 56 lb. placed ¼ from low tower:—

+ ·81	+ ·12	— ·86

From this experiment it appears that the deflection is decreased by loading the bridge to $\frac{1}{26}$ of that of the girder unattached, and if the chain were without weight it would be still further reduced; in practice, however, the weight on the bridge will much exceed that on a model, and $\frac{1}{26}$ will be the least amount that will arise, a result so at variance with the pre-conceived notions of many engineers, that it is to be expected in some instances it will be received with incredulity; but an investigation will show that the result is in accordance with the law $\frac{Fw}{bd^2x}$ = a constant quantity.

If the girder were supported only in the middle, the deflection of the half girder would be ⅓, but as one half of the girder cannot deflect without the other half rising, from the action of the chain, it is reduced to $\frac{1}{15}$; but the girder is not supported at one point only, but at various points, which will still further reduce the deflection.

Prof. Rankine, who has arrived at the result by investigation alone, makes $\frac{1}{37}$ to be the true ratio, which I have adopted, and calculate the necessary dimensions of a girder as follows:—It being determined by the Board of Trade what amount of weight should be the test to produce a given deflection on half the girder, we may derive from existing girders the weight which must be given to such a span as the Niagara Bridge to reduce the wave to a given amount. Let us assume, for example, that 200 tons on one-half the span shall not produce a wave exceeding 2 inches. To deduce the result from the Boyne Viaduct, we have the ascertained fact that in a girder of 264 feet span the deflection with 540 tons all over was 1·9 inch.

The deflection, if of the length of the Niagara Bridge, would have been $264^3 : 280^3 : : 1{\cdot}9 : 57$ inches, $\frac{57}{27} = 2{\cdot}11$ inch, is therefore the deflection which would have been produced by a weight of 240 tons, and therefore 200 tons would produce ·79 inch deflection.

The weight of a girder of the same section as the Boyne Viaduct would be 932 tons; 264 : 820 : : 300 : 932 tons, and to produce 2 inches deflection, 368 tons if made of ordinary iron, but if made of superior metal the reduction of weight will be in proportion to the increased strength.

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To obtain the result from the Britannia Tube, we have as an ascertained fact that its weight is 1600 tons, and that its deflection with 200 tons all over is 1·25 inch; $240^3 : 820^3 :: 1{\cdot}25 : 7{\cdot}04$. The weight of the tube of 820 feet long would have been 2852 tons. The deflection, if attached to a chain, $\frac{7{\cdot}04}{27}$ ·26 inch.

The weight therefore to produce 2 inches deflection with 200 tons will be 370 tons, which nearly agrees with the calculations for the Boyne lattice bridge. To compare the Britannia Bridge with a suspension girder of the same span, and to produce the deflection, we have $\frac{w}{27}$ + weight of the chains = 500 tons.

Concluding Remarks.—By the above calculations we arrive at the result that spans much above 820 feet may be constructed even without improved metal where girders are not practicable; and that in large spans, where they are practicable, a suspension girder, tested with the same load and to the same deflection, will only require one-fifth or one-sixth of the metal, and will be a safer structure, from depending on the extension of the material. This result is the more important, because the advocates of parallel girders have acted on the assumption that the construction of a platform 450 feet long, sufficiently rigid for railway traffic, almost amounts to the construction of a girder itself.

When my paper was read at the Dublin meeting of the British Association (1857), there were several girder engineers present, but no observation was made during the discussion upon the especial object of my experiments, except by Prof. Rankine, who, as I before observed, investigated the subject on this point, and arrived at nearly the same result. The only observation made by other engineers was to the effect that there would be some oscillation or motion which could not be arrived at by mechanical investigation; but without any denial of the truth of the deductions of my experiments.

Now I venture to contend that the amount of deflection of a given girder with a given weight can as clearly be arrived at by investigation when it is attached, as when it is unattached, to a chain. There may be practical points more in favour of one mode of construction than another, which I am prepared as a practical man to discuss, but these are questions rather for the Institution of Civil Engineers; and whatever these practical failures may be, there must be a certain deflection which arises with a given force or weight applied, and it is this, the first and most important inquiry in every mechanical structure, which is alone the subject I am now desirous should be investigated and understood.

With reference to any supposed practical objections to suspension structures when applied to railways, even when the wave is cured, I will only observe, having had great experience in railway constructions, that I am unable to form an opinion without further explanation of what is referred to. Although some railway engineers adhere to the idea that no weight of girder will make a chain rigid, yet some of the most eminent men have expressed a contrary opinion. Telford, with whom I had the honour to serve for a time as pupil, and Sir W. Cubitt, whom I also served several years as resident engineer, and who has had great experience in railways, were both fully satisfied that the suspension construction might be adapted to all descriptions of bridges.

The late Mr. Rendel, who constructed the Inverness Bridge, and Mr. Vignoles, who constructed the Kief Bridge, in Russia, have expressed a similar opinion. Both of these bridges had stiffening girders of small depth, and the effect from observations made by passing loads (the Inverness Bridge having had a locomotive over it on a truck), fully bears out my calculation of the ratio of deflection with or without a chain.

I may add, that in America suspension bridges have been used for aqueducts with success as well as for a railway bridge; and that the wave of the Niagara Bridge, which has a girder of wood, is less than my calculation would give; in fact, I should have doubted whether any wooden girder construction could have reduced the wave of a span of 820 feet sufficiently for heavy traffic either for a road or a railway.

It may be true that public feeling is against suspension bridges, from the repeated failures arising from want of metal, and from having no means of curing the wave; which arises, as my model has shown, by the smallest weight applied at any one point; but this is only a reason why men of science should look at the question, and correct an error which is a check upon useful enterprise and upon the progress of public improvement.

When alluding to the adoption of a system of large spans for the relief of the London traffic, it was not intended to express a decided opinion that it is the best mode of removing the difficulty, although I believe on mature consideration it will be found to be so, as the objections to the other modes suggested are very great.

Tramways in the streets will be more beneficial than is probably expected; but as London streets are generally so narrow, little can be done by this system, unless stopping at shops or residences is prohibited except at appointed places.

The construction of a viaduct, consisting of a series of shops, with a railway on the top, and a street on each side, as suggested by Sir J. Paxton, would be the most perfect arrangement, but the cost would be serious, and the railway must follow the surface of the ground, or nearly so, which would render the gradients unfavourable.

The scheme however which contends with the greatest variety of difficulties, although actually in operation, is the tunnel under London. It is expensive, not only from destroying property on the surface, but from interfering with and disarranging the sewers, gas and water pipes, &c., under the surface. The passengers will be inconvenienced by travelling in the dark, and in a tunnel in which the atmosphere (being immediately under the surface of a crowded city) can be little better than that of a common sewer. An underground system has also the objection that the application is limited to the elevated parts of London, as, if below the level of high water, it would be liable to inundation. The use of steam power is also prohibited by act of parliament, and Parsey's air engine not being applicable, the girder system has in this respect, as well as others, the advantage, as steam power may be employed if necessary.

In conclusion I will however observe, that whether suspension girders are applicable or not to the particular purpose of London traffic, there are many cases where the benefit of railways may be extended by a safe and economical system of large spans, where they would otherwise be prohibited by the cost of execution; and I therefore trust not to have been in error, as far as relates to the mechanical points, in bringing this important subject before the British Association.

In the *discussion*, Mr. Barlow's views as to the sufficiency of a form of girder to impart stiffness to the roadway, were much contested, but were to a considerable extent supported by the president (Prof. Rankine). It appeared that very little was known to the speakers of the success of the application of the principle in the chief example referred to—the Niagara Bridge, whether regarding the manner of passing trains across it and the effects of strain, or the construction and dimensions of the bridge. What was known and put forward in the discussion, touched rather a question of strength of the several members of the construction, than that of the suspension principle as applied in the bridge. Mr. Fairbairn especially dwelt upon the fact, that when in the north of England experiments had been made on the effect of a railway train on a suspension-bridge, it had been found that the roadway rose in the form of a wave in front of the advancing engine.

Mr. Edward Hall observed that there were provisions in the Niagara Bridge to prevent the effects instanced by Mr. Fairbairn. The underside of the roadway was held down by inclined tension rods anchored to the piers, similarly to the arrangement in the Brighton chain pier, adopted after the storm some years since. It appeared to him therefore that the effects were not inevitable. He believed, also, that the Niagara Bridge was so far a successful work, that its engineer, Mr. Roeblin, was proceeding, or had proceeded, to the application of the principle to other bridges.

Mr. E. Cowper, who agreed with Mr. Barlow on the applicability of the suspension principle, but differed with him on the method of overcoming the disadvantages of the present suspension bridges, brought forward his own proposal for the construction of a rigid suspension bridge. He believed that the passage of rolling weights would rapidly destroy the bolts and rivets of the links of a chain; and would therefore substitute for the catenary of many links, a rigid piece of construction of rivetted boiler-plate of the same catenary figure, and of the usual form of section for girders, but so deep in the web or connection of top and bottom flanges, that the tensile strain, the only one to which it would be sub-

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jected, would follow a curve within the depth of the construction, and in either case whether of the bridge being loaded or not loaded. By this principle, rigidity in the roadway would be combined with the advantages of the suspension principle more effectually than by the addition of a girder.

On the Density of Saturated Steam, and on the Law of Expansion for Superheated Steam. By WILLIAM FAIRBAIRN, F.R.S.

AT the last meeting of the British Association, I detailed a new method of ascertaining the specific gravity of vapours, which, in conjunction with my friend Mr. Tate, I was employing with a view to ascertain the density of steam at all temperatures. It may be of interest to the Association to know, that I believe the method to have proved itself reliable, and that we have now experimental determinations of the density of steam; and these fully verify the anticipations of Mr. Thomson and Mr. Rankine, that the vapour of water does not accurately obey the gaseous laws. We have found the density of saturated steam always greater than that given by the gaseous steam, even for temperatures as low as 136° Fahr., and for pressures less than that of the atmosphere.

The experiments as they stand at present extend over a range of temperature from 136° to 292° Fahr., or from 2·6 to 60 lb. pressure per square inch. But as we hope to extend them to higher pressures, I have preferred to leave at present the consideration of their bearing on other formulæ, and the ultimate generalisations to which they may lead in regard to the use of steam. The following simple formula, however, very nearly expresses the results of the experiments as to the density and pressure of saturated steam, the relation between pressure and temperature having been already determined with scrupulous accuracy by the elaborate investigations of Regnault.

Let V be the specific volume of the steam or volume as compared with that of an equal weight of water; P=the pressure in inches of mercury. Then I find

$$V = 25{\cdot}62 + \frac{49513}{P + {\cdot}72}$$

Table of Results, showing the Relation of Density and Pressure of Saturated Steam.

No.	Pressure. In lbs. per square inch.	Pressure. In inches of mercury.	Temperature, Fahrenheit.	Specific volume. From experiment.	Specific volume. By formula.	Proportional error of formula.
1	2·6	5·35	136·77	8266	8183	+ 1-100
2	4·3	8·62	155·33	5326	5326	0
3	4·7	9·45	159·36	4914	4900	— 1-350
4	6·2	12·47	170·92	3717	3766	+ 1-74
5	6·3	12·61	171·48	3710	3740	+ 1-123
6	6·8	13·62	174·92	3433	3478	+ 1-76
7	8·0	16·01	182·30	3046	2985	— 1-50
8	9·1	18·36	188·30	2620	2620	0
9	11·3	22·88	198·78	2146	2124	— 1-97
1	26·5	53·61	242·90	941	937	— 1-235
2	27·4	55·52	244·82	906	906	0
3	27·6	55·89	245·22	891	900	+ 1-100
4	33·1	66·84	255·50	758	758	0
5	37·8	76·20	263·14	648	669	+ 1-32
6	40·3	81·53	267·21	634	628	— 1-100
7	41·7	84·20	269·20	604	608	+ 1-150
8	45·7	92·23	274·76	583	562	— 1-29
9	49·4	99·60	279·42	514	519	+ 1-100
11	51·7	104·54	282·58	496	496	0
12	55·9	112·78	287·25	457	461	+ 1-114
13	60·6	122·25	292·53	432	428	— 1-108
14	56·7	114·25	288·25	448	456	+ 1-56

The above table exhibits accurately the results at which we have arrived in regard to saturated steam: we have also obtained some results on the rate of expansion of superheated steam. These results are at present less complete than those upon saturated steam, as they do not range more than 20 degrees of temperature in each case above the maximum temperature of saturation. They appear however to show conclusively, that near the saturation point steam expands very irregularly, thus agreeing with what we know of other bodies in their physical relations at or near the point at which they change their state of aggregation. Close to the saturation point we find a very high rate of expansion, but this rapidly declines as the steam superheats, and at no great distance above it the rate of expansion nearly approximates to that of a perfect gas.

Thus for instance, in Experiment 6, where the point of maximum saturation was 174·92°, between this and 180° the steam expanded at the rate of $\frac{1}{180}$, whereas air would have expanded $\frac{1}{184}$; but on continuing the superheating the co-efficient was reduced between 180° and 200° from $\frac{1}{190}$ to $\frac{1}{217}$, and for air the co-efficient would have been $\frac{1}{230}$ or almost exactly the same: and this rule holds good in every experiment; a high rate of expansion close to the saturation point diminishing rapidly to an approximation to that of air.

Street Railways. By G. F. TRAIN, of Boston, U.S.

THE age of omnibuses in crowded cities has passed;—the age of horse railways has commenced. America has introduced the new invention of relieving crowded streets by giving additional facilities for travel; and Europe must sooner or later adopt a similar system. While on a recent visit to the United States, I was surprised to find the progress that had been made in what the Americans call Horse Railways. In the cities of Boston, New York, Philadelphia, Baltimore, St. Louis, and Cincinnati, the railway cars were displacing omnibuses in all the large streets. Like all practical, labour-saving inventions, the people first oppose, then advocate them. They have already become a public utility; and Americans would miss their railway cars as much as the English would their penny-postage system. The horse railway is a fixed fact. It has had a fair trial, and has met with striking success. The horse railway is creating, and will continue to create, the same revolution in large cities that the telegraph on land and the electric cable under the ocean has done in commerce. As the locomotive supersedes the stage-coach on the shore, and the steam-boat displaces the sailing vessel on the sea, so will horse railways make omnibuses give way to the force of progress.

The railway from Liverpool to Manchester, in your recollection, astonished the world;—now there are 70,000 miles! Brunel's genius progressed from the Great Western of 2000 tons to the Great Eastern of 20,000 tons in twenty years. Now a thousand steam vessels connect the mother land with her colonial children, as the arteries carry life from the heart.

England, first in iron railing the country with steam, is last in iron railing the city with horse-power. But the enterprise that stimulated the Thames Tunnel, the Tubular Bridge, the Crystal Palace, and Great Eastern, will not long submit to the miserable steam-packets from England to France, ferry-boats from Liverpool to Birkenhead, or to omnibuses blockading the leading thoroughfares. The latter enterprises, I am confident, on the improved system, would prove as great financial successes as the former have financial failures. Although the Americans have seized the idea, and are practically demonstrating it by introducing horse railways into all their large cities, as if it was a modern invention, I find that there is nothing new after all in the system, except its application for passengers. A century ago tramways were used in England.

Cæsar's military roads from hill to hill still mark the Romans' track. First pack-horses transported the products of the land from place to place. Even a hundred years ago this was the custom in Scotland; in fact, in some places in the Highlands and in some of the hilly parts of Wales it is the practice of to-day. Wooden sledges drawn by horses succeeded; then wheel carriages —afterwards wooden tramways—and last came what the Egyptians used in the age of the pyramids, and the Chinese during the Christian era—canals; the first in England was made in 1756. The Asiatic practice of laying down timber in bad roads most likely introduced the wooden rail. Down to the Elizabethan age coals from Newcastle were taken in carts or in panniers to the sea. Wooden railways were introduced previous to 1649. Two tons were a good load for one horse on the wooden rail; this is now about the weight of the passenger car. In 1738 cast-iron rails succeeded wood. In 1752 iron wheels were made, but the carriages were not linked together till 1763. Six tons of rails were made by the Colebrook Dale Company for their tramway on the 13th November of that year; and the Ebbw Vale Company, nearly a century after, are rolling their first 300 tons of street rails for the Birkenhead Street Railway. In 1805 malleable rails were made at Wall-bottle Colliery, Newcastle-upon-Tyne.

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After horse-power came steam. Savery reduced to practice in 1663 the Marquis of Worcester's suggestion in the 'Century of Inventions.' Newcomen made improvements in 1707. The cylinder and piston high-pressure engine came in 1720. These engines were used to pump water, but Dr. Robertson suggested to Watt, in 1759, the idea of making steam move wheel carriages. The Surrey Iron Railway Company, in 1801, was the first railway act passed in the kingdom. In the year that Wellington and Napoleon were born, 1769, Hornblower introduced his patent. In 1782 Murdock made his model-engine. Trevithick and Vivian, in 1802, reduced theory to practice, and obtained a patent for propelling by steam. The first trial was on common roads. Thousands saw the experiment where the Euston-square station now stands. Woolf made improvements in 1804; but George Stephenson, just before the battle of Waterloo, invented the steam-blast, which was the life-blood of the steam engine. Five hundred pounds premium was offered in April 1829, by the directors of the London and Manchester Railroad, for the best locomotive engine, to draw three times its own weight over a level plain 10 miles an hour, weight not to exceed 6 tons, to cost not over £550. October 6, 1829, was the first trial day, and imagine the sensation produced by the engine running 28 miles an hour! The last day in that year the first railway in England was opened for passengers. On the 4th of December 1830, Stephenson's engine, "The Planet," took 135 bales of cotton to Manchester. Thirty years later there were 10,000 miles in England; and in America 5000 miles more of railway in active operation than is necessary to circumnavigate the globe! This rapid glance from Roman days to our time gives each stepping-stone from pack-horses to locomotives.

Sir Benjamin Hall—if the short-hand notes taken at the interview between the Chief Commissioner and the representatives of the London Tramway Company, two years ago, are reliable—seems to have thrown cold water on the deputation. He did not meet the arguments of Messrs. Coates and Samuel, except by prejudice. Arguing against facts is difficult, and over-riding stubborn truths impossible; and in September next sceptics will have an ocular demonstration of what I have undertaken to explain to this meeting.

The following are the advantages of the street railways:—

1. Each railway car displaces two omnibuses and four horses, thus relieving the streets of one of the main causes of the oft-recurring lock-ups.

2. The wear and tear from these omnibuses being transferred to the rail, as well as that of many other vehicles that prefer the smooth surface of the iron to the uneven stone pavement, the ratepayers save a large percentage in taxes.

3. The gas and water commissioners are not inconvenienced when making repairs, as the rails are laid on longitudinal sleepers, which can be diverted in case of need; and as these cars, as well as the carts and carriages that take the rail, move on a direct line, it is a self-constituted police system, saving confusion without expense to the public.

4. The cars move one-third faster than the omnibus; and so gentle is the motion that the passenger can read his journal without difficulty.

5. The rails are so constructed that no inconvenience arises at crossings from wrenching off carriage wheels; and as the improved rail is nearly flat, even with the surface, and some five inches wide, no grooves impede the general traffic, and the gauge admits all vehicles that prefer the track to the pavement.

6. The facility of getting in and out at each end of the car and on each side, giving the passengers the choice of four places, together with the almost instantaneous stoppage by means of the patent brake, permits travellers to step in or out when in motion without danger, instanced by the fact that nearly seventy millions of passengers passed over the New York, Boston, and Philadelphia roads last year, with only twelve accidents.

7. In case of necessity troops can be transported from one part of the city to the other at ten miles an hour.

8. It is a special boon to the working man to buy a ticket from his work in the city to his cottage in the suburbs.

In short, the horse railway is as much a necessity as gas, sewerage, the steam rail, or the electric telegraph. Once introduced, you would miss the passenger car as much as any great public benefit.

The advantages of this system are, that you ride in less time; with less confusion; less noise; less fear of accident; less mud and dust: and with the additional luxury of more regularity; more attention; more comfort; more room; better light; better ventilation; and a greater facility of ingress and egress.

Birkenhead will have the credit of introducing the first street railway on this side of the Atlantic. The Ebbw Vale Company have agreed to deliver the iron in July; Messrs. Crowe and Williams are preparing the timber; Mr. R. Main is at work on the carriages, to be ready in August; Mr. Charles Burn, the contractor, will break ground the moment the material is at hand, under the engineership of Mr. Samuel, of London, and Mr. Palles, of Philadelphia, the resident engineer; and in September, Mr. R. Peniston, the secretary of the "Birkenhead Street Railway Company (Limited)," will issue excursion tickets from Liverpool to Birkenhead Park and back for sixpence.

Street railways in England will soon become a great fact. Birkenhead opens the ball; Liverpool follows; then Manchester, Birmingham, Glasgow, and Dublin; and London cannot well hold back after building the Metropolitan Subterranean Railway. A street railway can be constructed directly over it, in as many months as that will require years. The former costs £3000 per mile; the latter £300,000. In the one you travel in the dark; in the other in broad daylight! (Who crosses in the Thames tunnel?) The former stops before every man's door; the latter has stations only at intervals. One starts every five minutes; the other every half minute if required. The Metropolitan blocks up the thoroughfares for months; the street railway for hours only.

Are not the streets of London too narrow? By no means. London streets are wider than those in American cities. Ludgate-hill and Cheapside are of course in your mind. But when we remember that there are some five hundred miles of street in and about London adapted to this system, why select the narrowest to commence with. First construct a line from Bayswater, through Oxford-terrace and the New-road, to the Bank; then another line over Westminster Bridge, down those wide solitary streets on the Surrey side, to London Bridge, with a branch over Waterloo to the Strand. This would relieve Fleet-street of a thousand omnibuses, and thus make way for a single line down the centre of the city, to return by another route.

Mr. Train stated his car would accommodate inside and out 60 passengers; that the weight of the car was two tons. Two horses would be equal to a gradient of 1 in 30, but that for a gradient exceeding that an additional horse might be employed. On the street rail two horses would be five times more than two on the ordinary road.

In the course of the *discussion* which followed,

Dr. CARPENTER, of Warrington, said he had just returned from America, where he had travelled a great deal in these street railway cars, and was strongly impressed with their advantages. One of the great advantages of these cars was the facility of ingress and egress which they afforded at each end, even when in motion. They afforded plenty of room for the passengers, and, in consequence of carrying so many, the fares were as low as 5 cents, or 2½d., for almost any distance. It was asked whether street railways would be inconvenient to the general traffic? it was not found so at Boston, which was most like an English town, on account of its crooked streets; the city was limited in its room, being built on a peninsula, but the system of these horse railway cars worked remarkably well. When all the omnibus traffic and general traffic was one line, and one of these cars took the place of so many other omnibuses, then the streets were considerably lessened of their traffic and confusion. In the streets which were very narrow the lines might be laid in parallel streets, as was the case in Broadway, New York; and the same might be done in the Strand and at Ludgate-hill, in London. In some streets which were wide double lines might be laid down, and single lines in narrower ones; and, where the ascent was steep, the difficulty could be obviated by the employment of an additional horse on that particular part. One great advantage was the extreme quickness with which you travelled from place to place. One of the great objections to street railways was that a stoppage in any part would inconvenience the rest, but a plan had been introduced by Messrs. Mayne to obviate that, by having an eccentric flange. There was a plain wheel, and at the side an eccentric ring or disc, and by turning a lever it converted it into a railway carriage, and by turning it back it got on the common road.

Prof. RANKINE (the president) said that the system of street railways would doubtless have been introduced and adopted before now, had it not been that the public attention and the attention of engineers had been directed mainly towards perfecting the railway system, which comprehended a wider range, and was not restricted to large towns or a locality. He was not insensible to the value of the system of street railways, his father and himself having constructed one, by which they used to convey forty

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passengers with one horse up ascents varying from 1 in 66 to 1 in 40, at the rate of 5 miles an hour, their average speed on the level being at 10 and 12 miles. They had level crossings, but yet met with no accident, and although there were continually trains of coal waggons, no difficulty was found in passing them; and there was this convenience, that they could stop when they liked, almost instantaneously, and set down a farmer on his own farm, instead of setting him down at a considerable distance from it. That was the Edinburgh and Dalkeith line, but it was afterwards bought up and worked with locomotives, so that the horse-power was discontinued. Horse-rails had in fact come to be looked on as an exploded system, and but for that reason they might have been introduced here earlier and to a great extent. Having had considerable experience in this matter, he was bound to say that he saw no difficulty in carrying on the traffic in our streets on this improved system; and, so far from its being an obstacle, great facilities would be obtained, for they would reach their destination earlier, and the size of the railway cars affording increased accommodation, would lessen the number, and thereby lessen the pressure which was now felt in the streets of large and populous places. The rails themselves, constructed as proposed by Mr. Train, presented no obstacle, and would not interfere with the ordinary use of the road, whereas the width of the rails rendered them available by vehicles in general use. As far as his experience went, there was no difficulty whatever in getting round curves of great sharpness, or steep ascents. By Mr. Train's plan brakes were employed, which could be made use of either by the driver or conductor, or both, so that they could stop the fore or hind wheels, or both if necessary. The carriages were of light construction, and not liable to vibration or oscillation; and all these circumstances led him to believe that they would prove as practicable and as free from danger here as they had in the United States. He felt perfectly confident that when they were introduced into this country they would prove as great a boon as they had in America. With regard to steep ascents, all that was required was an additional horse; but with respect to Ludgate-hill and Holborn-hill, he was still of opinion that the only effectual way of dealing with them was by viaduct.

Mr. TRAIN replied, that as he proposed to make his rail along the centre of the street, it would leave the sides open for general traffic. As to stoppages on the line, he did not anticipate any, as the increased accommodation of the cars would so materially lessen the number of vehicles, that a stoppage was not likely to be so common as at present, in addition to which the traffic would be more divided, and there might be branches, where what might be likely to be impediments could be shunted. As to the ease with which such railways could be constructed, he had entered into a contract to complete that at Birkenhead in thirty days from the time of his breaking the ground. Mr. Train explained that the lines might be used for passenger traffic by day, and for goods traffic by night.

On Improvements in High-pressure Water Meters.

By DAVID CHADWICK, A. Inst. C.E.

IN introducing a new water meter to the notice of the Section, the author claims for it several improvements in mechanical arrangement of great practical value.

The determination of the best construction of water meters is acknowledged to be a subject of great importance, to both water companies as sellers, and to the public generally as buyers, of water. There is no valid reason, if a suitable measuring apparatus can be obtained, why water should not generally be bought and sold by measure, the same as gas and any other article or commodity. The price of water for trade purposes varies from 3*d.* to 2*s.* per thousand gallons. If 9*d.* per thousand gallons be taken as the average rate, it is equal to 4*s.* 9*d.* per thousand cubic feet, which is more than the average price of gas. It may therefore be taken that the average charge for water by meter is as great, if not greater, than the average price of gas by meter. Although very frequent complaints have been made as to the defective registration under certain circumstances of some of the gas meters in general use, no one at this day entertains the idea of either buying or selling gas otherwise than by measure.

Referring to the very great difference in the charge in various towns for a small and large quantity of water, we may inquire, Why then should not water be bought and sold by meter for all trade purposes, public-houses, stables, baths, closets, and all places where cisterns with ball-taps and overflow pipes are used, or wherever water is liable to be frequently or continuously wasted? The only answer to this question is, that until about seven years ago no high-pressure meter had been constructed on which any reliance could be placed; and the immediate and general use of water meters is only now restricted by the doubts and fears expressed in regard to their efficiency and durability.

There are at the present time about 10,000 high-pressure water meters in use in Europe, of which about one-half are of the kind known as "inferential meters," such as Siemens', and Adamson's, Taylor's, Mitchell's, and others; and the remainder are "positive meters," working on the principle of the piston and cylinder,* such as Kennedy's, Worthington's, Jopling's, Duncan's, and Chadwick and Frost's. If no serious practical objection had hitherto existed to the adoption of water meters it is within reasonable probability that the number now in use would have been a hundred times greater than it is.

In order to obtain a satisfactory view of the subject it will be requisite briefly to review the progress of invention to the present time, and to select the meters now in use, and ascertain to what extent the alleged defects in their construction and mode of action are susceptible of improvement; and lastly, to consider if the new piston meter of Chadwick and Frost has in an efficient and satisfactory manner overcome these defects. Although this inquiry may involve a reference to the alleged defects of the meters now in general use, the writer hopes to make such reference in a fair and candid manner, and with the greatest respect and appreciation for all who have devoted the requisite skill, energy, and perseverance, to make any valuable contribution to our knowledge on this difficult subject.

In the paper read by the author at the Institution of Civil Engineers,† in May 1854, he gave a list of all the patents obtained for improvements in water meters from 1824 (the earliest patented invention on this subject) to June 22, 1853. Since that date to the present 61 patents for water meters have been obtained, which with those previous to June 22, 1853, enumerated in the author's previous paper, may be classified as follows:—

Year.	Low-pressure Meters.	High-pressure Meters.			Total.
	Revolving buckets, oscillating chambers floats, &c.	Piston and cylinder.	Diaphragms, flexible chambers, &c.	Spiral fan, turbines, and drums.	
1824 to 1854	7	8	11	16	42
1854 to 1860	7	13	32	9	61
	14	21	43	25	103

Of all the above meters, it may be safely affirmed that not more than six or seven are now in practical use, and only two in extensive use. Of inferential meters, those of Mr. Taylor and Mr. Siemens are the only ones which have been extensively used. Mr. Taylor's meter was described in the author's paper before referred to, and since that date its use has become very limited. Mr. Siemens' meter was fully described by him at the Institution of Civil Engineers, in December 1856, and was generally acknowledged to be an ingenious invention, notwithstanding certain defects were ascribed to it and to all meters acting on the inferential principle? Mr. Siemens acknowledged that under certain circumstances "his meter would allow a certain small quantity of water to pass unmeasured."

It must be admitted that the principle of measuring by inference from the revolutions of a wheel, spiral fan, or turbine, does not present to the mind that conclusive evidence of exactitude we are accustomed to demand in our dealings with other matters, and this feeling of uncertainty is increased when it is known that these meters, even with the most perfect possible workmanship, must allow a certain amount of leakage, varying according to the size of the meter, when used under circumstances in which the velocity of the current is insufficient to overcome the friction of the working parts of the machine.

Kennedy's piston meter has, since the adoption of Woodcock's patent india-rubber rolling packing, been more extensively used than any other of its kind. The defects pointed out as existing in it and capable of improvement, in addition to its very great bulk and weight, are:—1. The necessity of using a tumbling lever and weight to change the position of the valves, and the liability to derangement by the constant recurrence of this strain. 2. The necessity for constant inspection in order to lubricate the working parts at the top of the meter. 3. The mode of changing the direction of the current by a plug-cock,

* Nearly all those meters worked on the principle of the diaphragm, or in which a flexible material has been used as the measuring chamber, have fallen into disuse.

† See *C. E. & A. Journal*, vol. xvii. p. 236.

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merely passing over, without completely closing the ports. This objectionable expedient has apparently become an absolute necessity in this meter in order to overcome the concussion which would be occasioned on reversing the valves at each stroke of the piston, and hence the further objection exists that these valves can be easily fixed across the ports, so that the tumbling weight will not act, and the piston will continue to work and the water pass through the meter at almost full bore, without any registration being given by the index.

Mr. Jopling's meter is almost identical with the invention of Mr. Worthington, of New York, patented in England forty-two days before it. By using two cylinders and pistons working alternately in a cast-iron chamber constantly filled with water, he has successfully overcome the objection to Mr. Kennedy's meter in regard to lubrication, the tumbling weight, and the liability to be tampered with by fixing the valve so as to allow leakage. But in accomplishing these results he has been compelled to introduce several complications in his machine which may prevent its being brought into much practical use. The defects may be stated thus:—1. The use of two measuring cylinders and pistons, which can only work alternately; double the space is therefore necessary to accomplish the same purpose as that effected by meters using a piston and cylinder with a reciprocating action. 2. The necessity for having two sets of slide valves, and of inclosing the whole in a cast-iron case sufficiently strong to resist the pressure. 3. The absence of any contrivance to secure either uniformity in the length of the stroke of the piston under various velocities of discharge, or of indicating only the actual length of each stroke.

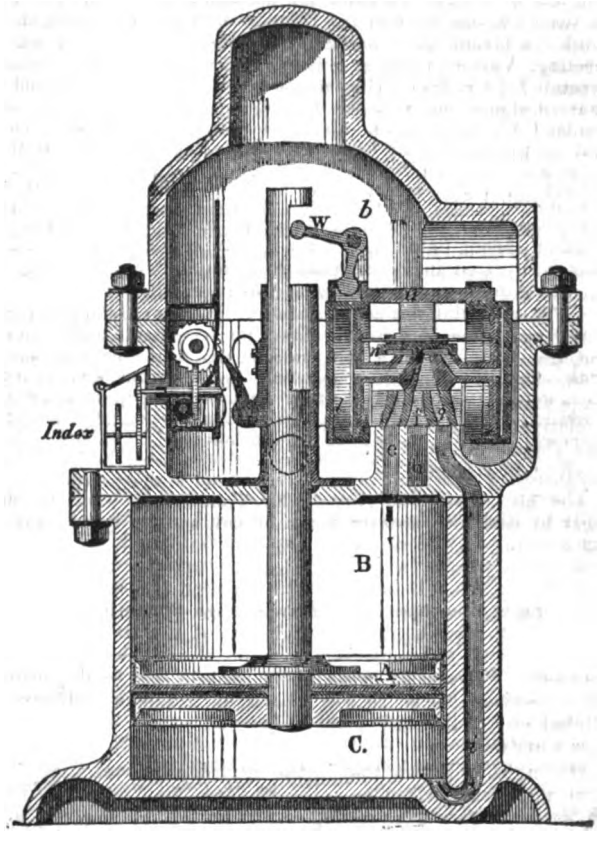
The use of Mr. Duncan's meter has been confined exclusively to Liverpool. It consists of two cylinders placed parallel to each other, each having a separate piston rod communicating by valve rods with separate slide valves, the two pistons being connected by a crank motion. These pistons were at first packed with a composition of gutta-percha and black-lead, but they are now packed with hemp, and work into cylinders of bored iron, and are therefore very likely to entail a large amount of attention to keep the various parts lubricated, and to replace the packing of the pistons.

The new high-pressure meter patented by Messrs. Chadwick and Frost, and now manufactured by the Manchester Water Meter Company, it is submitted effectually overcomes the difficulties and objections noticed in regard to other meters. It consists of a vertical cylinder and piston, with a reciprocating action. The cylinder is lined with brass, and the piston packed with cupped leather. The piston-rod passes through a stuffing-box at the top of the measuring cylinder, into a separated valve chamber, to which there is no connection with the measuring cylinder excepting through the ports of a slide valve, the two ends of the moving parts of which form pistons working in small cups or cylinders, and on the top of this valve a second slide valve works. When the main piston has fully completed its stroke, a projecting portion of the rod comes in contact with a catch, which moves the top slide valve, and admits the full pressure of the water to one of the cups, whilst it at the same time opens a way for the discharge of the water from the opposite cup, and the pressure so exerted moves the main valve by which the flow of water is reversed and directed into the other end of the measuring cylinder until the completion of another stroke, when the like motion is again repeated. The opening of the top valve to admit the water to the small cups at the completion of each stroke entirely prevents all concussion on the change of the valve.

In the annexed sectional illustration the meter is shown working. The water is entering, through the sieve or grating, the upper chamber of the meter *b*, and is passing down *e* into the measuring cylinder B; the pressure of the water being exerted in forcing the piston A to the bottom of the cylinder: the water is being expelled out of the lower part of the cylinder C up *i* and *g*, down *f*, and out at A. On the completion of the stroke of the piston the projecting end of the piston rod carries with it the catch W, which moves the top slide valve *u*, and removes the pressure from the small cylinder or cup *l*, and admits it into the opposite cylinder or cup, whereby the fluid pressure is exerted directly against the end of the main valve J, and changes its position, and thus reverses the action of the meter instantaneously, and without any noise or concussion.

Each stroke of the piston is communicated to the index by a ratchet wheel, and the exact quantity of water discharged is duly registered. The length of each stroke under all variations of discharge is exactly the same, and the measurement is consequently uniform and correct. All the parts work in water, and no lubrication of any kind is required. There is comparatively little wear on the faces of the slide valve, as they are subject only to the small difference of pressure between the area of their upper and under surfaces. The faces of these valves are made perfectly true, by finishing and scraping in the mode introduced by Mr. Whitworth, C.E., of Manchester; and no damage of any kind whatever has been found to arise, even when used with water containing sediment, sand, or other particles, which so injuriously affect all plug valves.

This meter was at first made with the cylinder working horizontally, and the piston-rod loose, but practical use has demonstrated the superiority of having the cylinder vertical and the piston-rod fixed. Nearly three hundred of these meters have been in use during the last two years, and the result has been to confirm the anticipations of their efficiency and correctness in every respect.



In the course of the *discussion*, Mr. Kell said he was connected with a company in the north of England where they had used a meter on the principle of the vortex wheel. This had been discontinued, in consequence of small shells becoming fixed in it, and interfering with the workings. They now used Kennedy's meter (which Mr. Chadwick had named as one of those on the piston and cylinder principle), and they had no reason to doubt its accuracy. Consumption of water for domestic purposes they found to be 25 to 35 gallons per day. Waste of a portion of this quantity could not be prevented; the small houses not having meters.—The chairman stated with regard to waste, that the inhabitants of Glasgow, since the supply from Loch Katrine, drew about 50 gallons per head per day. One family had drawn 2500 gallons daily; and many families drew two-thirds more than they used.

On Road Locomotives. By the Earl of Caithness.

My present object is not to enter into any detailed history of the steam engine from its commencement, or to trace its gradual improvement, but to place before you as briefly as possible some of the advantages that may accrue from it as a means of transit on our common roads.

The public mind is usually set against anything new. When,

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steamers were first spoken of they were looked on as a most wild and dangerous expedient. They would be constantly on fire,—would not, or could not, go to sea,—and if they did, who would be found mad enough go to with them? Mr. Miller, of Dalswinton, found this to the cost of mind and person; and Mr. Bell, though more successful with his first boat on the Clyde, had his battle to fight against public opinion. Railways at first were looked on as wild and visionary, and dangerous in the extreme to her Majesty's subjects. Thanks to George Stephenson, his perseverance had its reward, not only to himself, but in a much larger degree to us.

My object is to lay before you what in my opinion may some day work nearly as great a benefit on society as our railways. The subject is not new, but I am not aware that it has ever been brought before the British Association. It is road locomotion by steam. It seems the more important at this time to discuss the subject, as at present a bill is before parliament to enact certain tolls on locomotives; and so much fear is expressed by various parties as to the freedom from danger of these machines, that I think it a favourable opportunity to bring the subject before the meeting. Various plans have been tried, and vast sums of money expended, in endeavouring to perfect a good road locomotive. Watt designed one to carry two persons, but it was not constructed, his other employment taking up so much time as to prevent him carrying it out. The first actual steam carriage we read of was made by a Frenchman named Cugnot, who showed it to Marshal Saxe in 1763. He afterwards made one that, when first set in motion, went through a wall, and being by this means or other violent exhibition of its powers considered very dangerous, was placed in the Arsenal Museum at Paris, where it now is. An American, Oliver Evans, also invented a steam carriage in 1772, but it did not come into use. William Symington conceived the same idea for Scotland, but the roads were then so bad, that to speak in a slang way it was "no go;" this was in 1786. The next inventor was William Murdoch, who in 1784 made a model of a steam carriage, which is still in possession of a relative of Murdoch's. Another inventor of steam carriages was Thomas Allan of London, who in 1789 designed one to carry goods and passengers.

The most successful however seems to have been a locomotive built by Richard Trevethick, of Cornwall, and Andrew Vivian, his cousin, (Trevethick was a pupil of William Murdoch.) He took out a patent for it in 1802. His carriage was like a common stage-coach. It had only one cylinder. This was the first successful engine made to work with high-pressure, moving the piston both ways against the pressure of the atmosphere only. The first road steam-carriage was, on the whole, wonderfully successful. It caused great excitement in his neighbourhood. This carriage safely reached London, and was publicly exhibited on an inclosed piece of ground where Euston-station now stands.

Having thus shown that in the early days of steam, carriages were made and driven on common roads, I am about to bring the subject before this meeting, in the hope if it is now taken up, and backed by the British Association, we shall have this most useful, and now well understood power, brought to bear as a most efficient means of conveying heavy goods and passengers, as tenders to our railways, instead of making so many short branches of railways that do not pay.

Mr. Scott Russell, many years ago, made a successful steam carriage that ran between Glasgow and Paisley; and if it had not been for a most unfortunate misunderstanding between the promoters of the carriage and the road trustees, whereby a fatal accident took place, I believe it would then have made a great stride in the right direction. It performed its journey very well for some time.

One of the great reasons why we may now look for success in road locomotives is, that instead of as formerly having a heavy machine or carriage worked with a comparatively light pressure of steam, we now have a light carriage and worked at a heavy pressure. We now have the means of making very strong boilers very light, and to stand a high pressure.

A number of plans have been tried, all more or less successful. The first that came out of late was Mr. Boydell's, with its endless railway attached to its wheels. This carriage, though I have not seen it at work, has, I understand, drawn great weights after it, at a cost much less than that of horse-power; and though clumsy in appearance, yet that may be got over. The first thing in my mind is to establish the actual working of this mode of hauling.

We have now another and also a most successful steam carriage in Mr. Bray's. It is very ingenious. It has now been working for some time with perfect success; and though it was unfortunately transmogrified last year into a green dragon, and for a time gave in, yet there is no reason why it should not turn out a most useful machine. Indeed it has proved itself so a great many times within a few months, in taking large loads through London. It has drawn over thirty tons through the most crowded thoroughfares of London, and in no instance has any accident occurred during its employment. The economy in its use has been equal to a saving of one half the cost of employing horse-power.

Mr. McConnell, to whom the world is largely indebted for very valuable improvements in the locomotive engine, has, I believe, undertaken to give his able attention to this subject, with a view to bring out a simpler engine than that now in use. This I feel can be done with ease, so as to make a much more workable and less costly machine. I think great speed should not be looked for in traction engines. What is wanted, in my opinion, is a means of taking large loads at a small cost. It is a great mistake to suppose that injury is done to the road by the use of steam carriages. The truth is that there is much less injury done than by using horses,—the broad wheels acting like rollers, and so rather improving than hurting the road.

The Marquis of Stafford has had a small steam carriage in use now for two years, and it works with great ease. It was made by Mr. Rickett, of Castle Foundry, Buckingham. Since it was made Mr. Rickett has made two others, introducing great improvements, being direct acting instead of being driven by a pitch chain. One of these carriages has been built for myself. It weighs one ton and a half, and I have had a speed of nearly twenty miles an hour out of it. I gave a suggestion as to the mode of placing the axle in connection with the driving gear, which I will explain. I placed the axle of the road wheel in radial segments, so that as the springs rise and fall by the action of the road, the driving gear or toothed wheels are never allowed to be at a greater distance from each other at any time; the axle as it rises or falls performing a part of a revolution round a crank shaft, on which is fixed the smaller wheel which gives the action to the road wheels. Its action is perfect, as the teeth of the wheels are always in gear to the same depth; and the consequence is that the springs act most perfectly, and it goes along the road without trouble. I have now had several trips on it from Buckingham to Wolverton, a distance of ten miles, and this has been done within the hour, including stoppages.

Another advantage of steam on roads over horse-power is, that instead of requiring twenty or thirty horses, forming quite a troop, to take a carriage containing some heavy weight, you place before the said carriage a steam engine. This power will cost but a small sum in comparison with horses: it will be a constant power so long as it gets coal and water. It will take up but little room, not being much larger than a common carriage. This seems a most important reason for the advancement of steam, as at this present day saving of time, money, space, and at the same gaining increase of power, are cogent reasons for advocating any cause.

On Rifled Cannon. By Capt. Blakely.

The author argued, that to make an efficient large rifled gun we need only copy any good small rifle, in the number and shape of grooves, degree of twist, and other details, provided we overcame one difficulty, viz., that of making the barrel strong enough. Taking Sir William Armstrong's 80-pounder as a standard, Capt. Blakely gave several examples of large rifled cannon on the model of successful small ones, which had given results satisfactory in every way, except that they failed after a short time from want of strength. Mr. James Lawrence in 1855 rifled a 6½-inch gun with three shallow broad grooves, like an Enfield rifle, and fired a lead and zinc bullet shaped like an Enfield bullet. At 5° elevation his range was 2600 yards—150 more than Sir William Armstrong's—but the gun burst after about 50 rounds. Mr. Whitworth, after making some excellent small arms and 9-pounders, tried a large gun with 4 inches bore and sides 9 inches thick, but it burst. He then tried another with sides 11 inches thick, and it too burst. He had since made a stronger cannon, whose success is absolute proof that the one

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thing wanting in the others was strength. Sir William Armstrong, after great success with 3 and 12-pounders, has lately tried 70-pounders, but although they range well, they burst after a very few rounds, and this manufacture has been abandoned.

Col. Cavallis's experience and that of Mr. Britton were alluded to, and then Capt. Blakely explained his own method of obtaining the necessary strength, which consists simply of building up the gun in concentric tubes, each compressing that within it. By this means the strain is diffused throughout the whole thickness of metal, and the inside is not unduly strained as in a hollow cylinder made in one piece. As the efficacy of this system depends entirely on the careful adjustment of the size of the layers, Capt. Blakely said he was not astonished that Sir William Armstrong had lately failed utterly in his attempt to carry it out, because he did not put on the outer layers and rings of metal with any calculated degree of tension; "they were simply applied with a sufficient difference of diameter to secure effective shrinkage," to quote his own words at the Institution of Civil Engineers. To show that the late failure by Sir William Armstrong did not disprove Capt. Blakely's theory, he then read the official reports of a trial of a 9-pounder made by himself in 1855, which showed an endurance seven-fold that of an iron service gun and three-fold that of a brass gun; also of an 8-inch gun, from which bolts weighing 4 cwt. had been fired, and of a 10-inch gun which had discharged bolts weighing 526 lb.

Mr. Whitworth's last new 80 pounder is another instance of the successful application of Capt. Blakely's principle. To quote Mr. Whitworth's own words, "It was made of homogeneous iron. Upon a tube having an external taper of about one inch, a series of hoops each about 20 inches long were forced by hydraulic pressure. Experiment enabled him to determine accurately what amount of pressure each hoop would bear. All the hoops were put on with the greatest amount of pressure they would withstand without being injured. A second series was forced over those first fixed." This gun was so made at Capt. Blakely's suggestion.

Captain Blakely exhibited in the court of the building a 56-pounder gun constructed on his own plans, from which he had thrown shells on Mr. Bashly Britton's system to a distance of 2760 yards, with only 5° of elevation, that being about 200 yards greater range than that of Sir W. Armstrong's 80-pounder.

After the reading of the paper, Dr. SCOFFERN said, he thought Capt. Blakely had quite proved his point, that if strength enough was given to a gun the rifling did not signify. He said that 110 of Sir W. Armstrong's large guns had lately been burst; but he was sure that if Capt. Blakely's plan was properly carried out, it would obviate this danger. He praised Mr. Lancaster's system for small arms.

Mr. COWPER agreed with Capt. Blakely, and explained the bursting of Mr. Lancaster's large guns, expressing however his approbation of that gentleman's system for small arms.

The President of Section A (Mathematical and Physical Science), in the course of his address, said—

The area of scientific research which this Section covers is very large,—larger perhaps than that of any other; and its subjects vary much. There are many and good reasons why these subjects should be grouped. Some of them possess, probably in the highest degree attainable by the human intellect, the characteristics of perfect and necessary science; while others are at present little more than a conglomeration of observations, made indeed with infinite skill and perseverance, and of the greatest value—capable probably in time of greater perfection, nay, perhaps of most perfect forms—but as yet in their infancy, scarcely indicating the process by which that maturity will be arrived at, and containing hardly the barest outline of their ultimate laws. We have indeed science intermediate to these two extremes, in which some of the laws are already capable of mathematical expression, and from which results have been derived; and still many phenomena are as yet not brought within their comprehension. But as all the subjects which we consider in this Section are of one type, so are they rightly combined; and it will be, I venture to think, an evil day for natural knowledge when we cease to consider the forms of the sciences of space, number, and motion those to which all others ought to assimilate themselves.

Now first of all in our Section stand Mathematics, both pure and applied. These indeed require very long and arduous study, inasmuch as they have peculiar nomenclature, language, and processes; and thus it is only to the few generally who have made them their particular study, that they offer great interest. Mathematics have also now become so large in their grasp and so curious in their detail, that I am only expressing the opinions of most analysts when I say that the whole of a man's life is not sufficient for more than one branch of them. Indeed, now, and we are proud to say so, some members of this Association are devoting whole lives, and intellects too of the highest order, to the advancement of our knowledge in a particular direction. Take, for instance, the theory of homogeneous forms; in the history of science the names of Boole, Cayley, Sylvester, will always be recorded, and in scientific treatises their labours will find a place. Or take, again, the theory of elliptic functions, or the calculus of probabilities, the difficulties of these subjects require the utmost tension of the human mind, and even then they transcend its limits. To many of the usual attendants on this Section, these and kindred subjects may be dry and uninteresting. If they are so to any of you I must beg you to bear with us for a short time; these theories have a deep and pregnant meaning. And be assured that they are not uninteresting to all: to many they give the purest pleasure, and I must ask you not to grudge them *that*, during the few papers on the higher mathematics which we shall probably have. I would remind you that very frequently our knowledge of natural phenomena depends on certain integrals, the properties of which can only be studied with a profound knowledge of the higher mathematics, and thus the progress of one branch of knowledge depends on, and is frequently stopped by our ignorance of, another. To most of us, probably, the questions of applied mathematics will have greater interest; we are more familiar with the laws of nature, the mathematical interpretation of which mixed mathematics, as they are called, takes cognizance of; we most eagerly catch at the results of those laws. The lunar disturbances have been, as you know, calculated with greater precision than heretofore, and new results have been arrived at which exhibit certain discrepancies relatively to the old. I need do no more than allude to what has lately taken place at our own Royal Astronomical Society and at the French Academy. Mathematicians however have been startled by an announcement that, "what is commonly called mathematical evidence is not so certain as many persons imagine, and that it ultimately depends on moral evidence;" and moreover we are told that "the results of long and complicated mathematical calculations are not more than probably true." This we can hardly believe. It takes us quite by surprise; and we hope for further light. If, however, we must wait for light, we must wait patiently; let us not forestall a conclusion which many of us venture to think is as yet, not to say more, unproved; let us wait for the new lunar theories, which are as yet unpublished, and for the new lunar tables, which are the results of these theories. I am told however already, that Baron Plana has corrected his calculations, and that he finds the results arrived at by Delaunay and Adams are in accordance with his amended formulæ. These new lunar calculations have taken us by surprise; but again I would say, let us wait: "*Magna est veritas et prævalebit.*" And before I proceed any further, we have a debt to pay which the cultivators of these branches of science owe,—to those I mean who have lately contributed reports on particular parts of our science to the British Association; to Mr. Cayley for his Report on the Present State of Theoretical Dynamics, and to Mr. Smith for the first part of his Report on the Theory of Numbers. It is only those who have had to go through the existing literature on any one problem,—say the theory of the motion of a rigid body,—who can form an adequate estimate of the value of such papers. The literature is catalogued, indexed, and analysed. We know thereby all that has been done up to a certain point; and, in our subsequent investigation, our commencement starts from the close of other men's labours.

On a New Geometrical Method of establishing the Theory of Conic Sections. By Dr. BOOTH.

ALTHOUGH for many years past our English Universities have promoted the cultivation of every geometry at all ranging above that comprised in the first six books of the Elements of Euclid, by algebraical methods, yet it may well be doubted whether in such elementary investigations it is the most eligible course to follow. Especially if it be true, as it unquestionably is, that the learner should be able at every step of his progress to transform

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into the pure conceptions of geometry those algebraical formulæ which, by the machinery, so to speak, of his analytical methods, he evolves step by step through his manipulation of mathematical symbols. What I mean is this, that the geometrical conceptions of geometrical truths should never be merged in the inspection of mere algebraical formulæ. In saying this I am not undervaluing algebraical methods. By the way, it is an abuse of terms arising from a confusion of ideas to use the words "analytical" and "algebraical" as synonymous expressions. Geometry has its analysis—and a very refined one—as well as algebra. I do not undervalue algebraic methods, quite the contrary, my researches have been principally in that direction. There are many geometrical truths which could never possibly be investigated by pure geometry. For example, the rectification of curves, and generally the quadrature of surfaces. There is a general rule which may serve to draw the line between those propositions that are best investigated by algebra, and those others in which geometrical methods will be found to answer better. That is to say, the graphical properties of space, such as projections, tangencies, convergencies, harmonic pencils, anharmonic ratios, and the like, may be in general more easily investigated by the help of geometrical methods, and real actual conceptions of the understanding; while on the other hand, quantitative properties, such as quadratures, rectifications, variations, and loci, are more effectively reduced by the help of algebraical methods.

There is also a large class of problems and theorems which formerly with great difficulty were subjected to the powers of common algebra as applied by the help of the common or Cartesian co-ordinates. That is to say, let us suppose a problem to be solved with simplicity and ease by the method of common co-ordinates, it would in general be found a task of extreme difficulty to solve the Reciprocal Problem by the help of the common system of co-ordinates. The solution was commonly effected by differentiation and elimination. Thus, let $V = 0$ be the equation of a surface containing a variable parameter x, which will be known by the conditions of the question. Then the solution in many cases will be obtained by eliminating a between the two equations $V = 0$, and $\frac{dV}{da} = 0$.

But we now know that any problem being once solved by the common or Cartesian co-ordinates, that is by the help of x, y, z, the reciprocal property may be exhibited and written down without any trouble, on a mere simple inspection by the method of tangential co-ordinates. By the tangential co-ordinates of a curved surface I would be understood to mean the reciprocals of the three segments of the axes of co-ordinates cut off by a tangent plane to a surface.

But to return to the subject more immediately before me. Many definitions of conic sections have been given. One of the most commonly known and followed is that of Boscovich, who defined a conic section as the loci of a point whose distances from a given point and from a given right line are in a constant ratio. Several treatises, indeed I may say most that have been written, are founded on this hypothesis. And the reason is very clear: the writer eludes the difficulty of conceiving the complicated intersections of planes with surfaces and lines. He gets at once into the smooth and beaten road of proportion, which is nothing but a disguised algebra.

More than half a century ago it was observed by an accomplished geometer, the Rev. Hugh Hamilton, Fellow of Trinity College, Dublin, that the properties of these curves might with more propriety be investigated in the cone itself, as any general properties of this surface must also hold good in its sections; and he almost stumbled on one of the most important theorems which are to be found in this inexhaustible field of mathematical investigation. It has recently been introduced into several elementary treatises, but I am not aware that any use has been made of it, much less that it has been made the basis of a theory. The theorem is the following:

A conic section being taken as a section of a right cone with a circular base, its foci are the two points in its plane which are touched by two spheres inscribed in the cone and touching the plane of the conic section; and if the planes of the circles along which the cone touches the sphere be produced to cut the plane of the conic section in two right lines, these right lines may be called the directrices of the conic section, and if the radical plane of these two focal spheres be drawn, it will cut the line that joins the foci in a point called the centre.

This simple and beautiful property, that the foci of a conic section are the points on which its plane touches two spheres inscribed in the cone, may be made the base of a geometrical system of conic sections. And I will venture to say that there is no other property of these lines that affords such short and simple demonstrations of many very difficult theorems. In fact I may here mention, that several years ago I drew up a treatise on conic sections treated geometrically, and based upon the focal property. The whole theory came out with marvellous simplicity and brevity. The demonstrations are almost contained in the constructions, or at most they seldom require more than two or three steps of a demonstration.

I amused myself at the time with showing how some of the most remote properties of these curves follow at once from the focal theorem. Besides, incidentally I stumbled on a few very curious theorems, which, as I have not met them elsewhere, I shall here mention.

If a tangent plane be drawn to a cone meeting any two parallel tangents to a section of it in the points A, B, and touching the inscribed focal spheres in the points C and D, the quadrilateral formed by joining these four points in the tangent plane has the sum of its opposite angles always equal to two right angles. A large number of theorems, some of them common and difficult to establish by the ordinary methods, follow as corollaries from this fertile principle.

Also, the semiparameter of any conic section is always equal to the perpendicular distance of its plane from the vertex of the cone, multiplied by the tangent of the semi-angle of the cone.

The angle between any two tangents to a conic section is equal to the angle which the two points of contact of the focal spheres with the tangent plane subtend at their intersection.

The locus of the intersection of rectangular tangents to a conic section is the sphere which passes through the two circles of contact along which the focal spheres touch the cone.

The sine of the angle between any two tangents to a conic section multiplied by the distances of their point of intersection from the foci varies as the perpendicular let fall from this point on a focal chord drawn through one of the points of contact, or $R r \sin \phi = 2aP$.

I will conclude by saying that these and other theorems better known may be established in a line or two of the simplest geometrical demonstration, that very seldom is it necessary to have recourse to those complicated proportions which deform the common treatises on the subject; and that the only difficulty to be surmounted is the want of practice in forming clear conceptions of the intersections and positions of planes and solids from their delineations on plane paper. I think the pains requisite to bestow in acquiring this facility is one of the greatest recommendations of the system.

On the Course of the Thames from Lechlade to Windsor, as ruled by the Geological Formations over which it passes. By the Rev. J. C. Clutterbuck.

We have only to look at the tortuous course of the Thames to see that there must be some physical cause which obliges it to deviate from that straight line that it would naturally take to its outfall. This is found in the obstruction of the various strata that it encounters. From Lechlade to Sandford it finds its bed in the Oxford clay, it then passes over the junction of that stratum with the Oxford clay above that spot and the Kimmeridge clay below; it holds its course under Nuneham Park beneath the escarpment of the iron sand, leaves this stratum at Culham, passes from the Kimmeridge to the gault near Appleford, flowing southward it passes over a ledge of the iron sand at Clifton Hampden, returns to the gault again, enters on the upper green sand near the junction of the Thame stream with the main river, till it passes to the chalk, in which it finds its bed to that point which was the limit proposed for our consideration.

Having described the course, it may first be remarked that the natural obstructions are found at the junction of the several strata: we have not now to consider the mechanical obstructions of mills at the side. At the present moment there is an unusual interest felt in this subject, for the very disastrous flood is now we think subsiding, but which has done more damage to the crops of grass than is within anyone's remembrance at any time.

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The water flowing down rivers, whether issuing from perennial sources by springs, or thrown from the surface as flood, is due to the geological condition of the district; I therefore proceed (directing your attention to the map of the river) to speak of the various tributaries or feeders, which discharge into the main stream more or less of perennial or flood water as they carry the water from permeable or impermeable strata. The Churn, the Coln, the Leach and Windrush, rise in the oolitic piles of Gloucestershire; their waters are for the most part perennial. The flooding of the upper portion of the Thames is due to the large extent of Oxford clay in the Bampton district, and the low level of the land; the removal of mechanical obstructions would relieve but not entirely remedy this evil. The Evenlode and Cherwell receive the drainage of the oolitic range at their sources on the impermeable beds of the lias beneath, hence they constitute a large portion of the flood waters, augmented by the large quantity thrown from the surface of the Oxford clay which is more or less developed above and around Oxford. The flooding of the Oxford meadows necessarily affects the sanitary condition of Oxford. This city is placed on a bed of gravel overlying the Oxford clay; from this source the wells are supplied, and it is worthy of remark that on the surface of the clay there are modulations which stanch back the water in the gravel. It was because one was cut through that many of the wells in Oxford lost their water in the case of the Jericho drainage. It was supposed that the surface of the Oxford meadows was Oxford clay; so it was laid down in the geological maps, and it was not till the so-called Railway Lake was made that it was discovered that the clay was covered with a deep bed of gravel at this and probably at other points. Thus happily on the subsidence of the floods the water filtrates to the gravel, and noxious evaporation from the surface is diminished. If ever any plan of side cutting should be carried out to relieve the meadows from the flood water, the existence of this bed of gravel should be borne in mind; as, if it were cut through, the supply of water to the Railway Lake, now so valuable to the town, might be endangered.

There is reason to believe that the bed of the river has in very many places been raised above its original level; evidence of this is supplied by the objects of antiquity found when constructing locks or weirs, or dredging for gravel. And as the period at which these arms or implements were in use is known, we have a fair guide to the period during which the accumulation has taken place. Thus at Sandford, arms of the age probably of Charles I. were found some eight feet below the river bed, and in other parts similar discoveries have been made. The phenomenon of the formation of ground ice, as it is called, and its power to carry stones and sand down the stream, when it rises to the surface, aggravates the natural obstructions in the stream. There is not time to dwell on all the points of interest which this subject suggests: it is one in which great local interest is felt in any remedies for the flooding of the rivers and the obstructions the water encounters. The geological question, which we can alone consider here, should be carefully considered, and may very reasonably occupy the attention of meetings like the present, as the ultimate object of all science should be practical improvement.

Notes on various efforts to Improve the Domiciliary Condition of the Labouring Classes. By HENRY ROBERTS, F.S.A.

The author stated numerous facts, the result of many years' experience, during which he has devoted much time to this object both in England and on the Continent. After referring to the occurrence of unexpected difficulties, not uncommon in the early stages of new undertakings, Mr. Roberts observed, that to be daunted by difficulties is foreign to the English character, and that this should be the case especially when the object in view is the benefit of our fellow-creatures.

Assuming that something of the actual domiciliary state of vast masses of our fellow-subjects is known to most, it was remarked, that "but few have sounded the depths of its misery or of its degradation, and none can fully estimate its evil results."

To remove the impression which has been produced by the want of pecuniary success in several instances, that dwellings of an improved character for working people cannot be built so as to be remunerative, reasons were adduced for the failures which have occurred; and facts were given tending to show that there had been a number of cases more or less successful. The Metropolitan Association for Improving the Dwellings of the Industrious Classes, from six buildings in different parts of the metropolis, on which £71,328 had been expended in providing accommodation for 395 *families*, had received for the past year, after deducting all current expenses and repairs, 3¾ per cent. on the outlay. On two lodging-houses for single men, one of them new, accommodating 234, the other old, which provides for 128, a considerable loss had arisen, in consequence of their not being fully occupied. The buildings in these instances must be either too large, or in some other way unadapted to the class of men frequenting the neighbourhood. A similar result had been experienced at Marseilles through the choice of a site outside the town, too far from the men's daily occupation; whilst at Leeds and Liverpool, in buildings on a smaller scale and better placed, increased accommodation had been required. Passing to a consideration of the undertakings of the Society for Improving the Condition of the Labouring Classes, although the accounts did not afford the same facility as in the other case for ascertaining the pecuniary return on the investment, the author showed that from the model buildings at Bagnigge-wells, Streatham-street, and George-street, the return collectively, after a deduction of ¾ per cent. for repairs, was in 1852 (when Mr. Roberts was honorary architect to this society), 4½ per cent. net. The return from the Streatham-street building, which is wholly for families, was higher than from the other two, being 5 per cent. net. The rents were fixed below those usually paid for a similar extent of accommodation. The new buildings in Portpool-lane were avowedly of so experimental and mixed a character, that the pecuniary results are not a criterion generally applicable. They may serve as a caution against providing too largely in one building for single women. The average occupation of 64 rooms has not exceeded 50 to 52, and more stringent regulations were required than in the men's lodging-houses. The public baths and wash-houses forming part of this building have not been remunerative. In his calculations of the return on the first-named piles of building, Mr. Roberts explained that 4 per cent. interest was allowed on the cost of the land, and ¾ per cent. for repairs, the buildings being new; on old buildings the repairs should be taken at 1½ to 2 per cent. In the case of two lodging-houses, which are old buildings and leasehold (one in Charles-street and the other in King-street), the clear return, after deducting 2 per cent. for repairs was at the period before mentioned 15 per cent. clear. In the case of three old courts in different localities, £7226 had been expended within the past six years in putting them into a good sanitary state, with suitable fittings, including a small lodging-house for single men, and the return had been much less satisfactory. In 1858 it was, after deducting 1½ per cent. for repairs, only about 1¼ per cent. on the outlay; and in the past year the net receipts had diminished considerably. Great as the improvement had been, the actual benefit resulting to the occupants of the courts, when they were taken by the society, was not to the extent which might be supposed, as a considerable portion of them had been ejected, not only to reduce the numbers within a due limit, but in order also to secure a more eligible class of tenants.

From the facts and figures given it would appear, that whilst old houses may be dealt with for men's lodging-houses with a fair prospect of remunerative return (though the results will depend on the manner in which the work is done, as well as on watchful management), courts and old buildings in the metropolis, put into sanitary condition and fitted up for families, unless obtainable at a much lower price than they usually are, will not yield a satisfactory return, after provision has been made for repairs and a sinking fund to pay off the capital, which there should be, especially in the case of leasehold property. It was however stated, that the Hastings Cottage Improvement Society had during the past three years succeeded in paying a dividend of 6 per cent. to their shareholders. It forms a main feature of that society's administration to disturb existing occupants as little as possible; and they have a reserve fund of 1 per cent. per annum.

The sanitary and moral results of the operations of the two London societies, need not be here recapitulated. The point required to be got at is, the reason for any ill success which there has been in the financial returns, and in the extent to which the example has been followed by speculators, or by philanthropists, who would gladly select the form of investment in buildings of the kind referred, were they assured of a moderate return. The sanitary and moral effects, taking them as a mere drop in the ocean, compared to the extent and vast population of London, the author did not consider were unimportant, or when com-

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pared with those in Paris, encouraged by a government subvention of 25,000,000 francs. For a description of what has been done in the British metropolis and elsewhere, the author referred to his paper on the Improvement of the Dwellings of the Labouring Classes, given in the 'Transactions of the National Association for the Promotion of Social Science,' for 1858.

Amongst the facts regarding financial success in London, it was stated that at Shadwell, close to the line of the Blackwall Railway, some miserable dwellings came into the possession of a gentleman, Mr. W. E. Hilliard, of Gray's-inn, who thereupon decided to endeavour to improve his own property, and also by example the immediate neighbourhood. The old dwellings were replaced by a street, with dwellings on Mr. Roberts's plan, as exhibited in 1851 in the Prince Consort's model houses. There are twenty-eight blocks, each of four residences,—112 families in all being provided for. The cost of each block was £487; and, after allowing for ground-rent and all charges, the authority of the owner was given that they continued to "pay upwards of 6 per cent., and in fact, nearly 7 per cent., as a net return on the investment;" whilst the same competent judge spoke of the facts as of "perhaps more consequence," that the houses were "almost constantly let," and were "appreciated by the tenants," who, "as a rule," were "pretty stationary, and not migratory as that class frequently are."

In the last-named case, we have thus an outlay of £14,000 on new buildings, containing 448 rooms, kitchens included, yielding 6 to 7 per cent.; whilst the cost of putting into sanitary condition the three old courts before alluded to, which contain 275 rooms, and a lodging-house with forty beds, had been upwards of £7000; and in that instance, the return on outlay has been 1¼ per cent., after deducting 1½ per cent for repairs, but making no allowance for sinking fund.

Mr. Roberts referred to the practical results of the interest taken by the Prince Consort in this object in connection with the Great Exhibition, in its having led in several instances to the providing accommodation for married soldiers: a want which led the late Duke of Wellington to object to the model houses being placed in the barrack-yard at Knightsbridge, lest it should cause dissatisfaction in the army. In the present session of parliament £30,000 have been voted for this object.

The Windsor Royal Society, with £9000 invested in new cottages and two lodging-houses, pays a dividend of 4 per cent. to the shareholders. At Liverpool, on a range of dwellings for 23 families in Upper Frederick Street, built after the general plan of the Exhibition model houses, 4¾ per cent. is realised. The association at Brighton has also built one block of six houses on the same plan, and a fair return is obtained.

Not fewer than twenty societies have been established in provincial towns, the results to occupants being in every case beneficial; and whilst the financial results have varied so far as to show the necessity of competent skill in planning, and watchful supervision, they are yet valuable. One instance from Scotland, that of the Pilrig model buildings, near Leith-walk, Edinburgh, was added by Mr. Roberts. There are forty-four dwellings in three blocks, with access on both sides, the upper floor tenements approached from one side, and the ground-floor from the other. By economy the cost was only £4052. 15*s.* 9*d.*, or about £92 per house. The rent of the whole is £303. 19*s.*, or varying from £5. 5*s.* to £9. 15*s.* per house, one half of them not exceeding £6. 6*s.* per house. The rents were purposely made low. After deduction of all expenses, namely, fee duty, £22. 14*s.* 10*d.*; insurance, £5. 12*s.* 6*d.*; rates and taxes, £13. 11*s.* 2½*d.*; repairs, £13. 4*s.* 7*d.*; management, £21. 6*s.* 3*d.*; and paying a dividend of 5 per cent. (less income tax), a balance of £30. 13*s.* 1*d.* was last year added to the sinking fund, from which sundry expenses, as painting and papering, are defrayed; this fund now amounting to nearly £200. The demand for the tenements is generally six times the supply.

Besides the instances which have been given, allusion was made to what has been done through a sense of duty and enlightened views of self-interest on the part of many landed proprietors and other employers of labour, as well as through the operations of building societies, the machinery of which might be further developed. Improved dwellings ought to be provided in the metropolis and elsewhere, as a consequence of the demolitions effected in the formation of new streets, and this should be rendered compulsory. An existing standing order of the House of Lords for the investigation of such cases has practically become a dead letter. The legislature should also interfere in the case of all tenements let at low rents in thickly populated towns, as they have done with so much success in the case of lodging-houses: such a power exists in the City, and is ably administered under the medical officer of health, to the great benefit of the poor and a sensible diminution of the mortality. The death rate in the City has diminished from 25 to 23 in 1000.

In conclusion, reference was made to the encouragement afforded by a recollection of the change which has taken place in the state of our prisons, which are no longer hot-beds of fever and moral contagion, as they formerly were.

In the *discussion* which followed, Mr. Edwin Chadwick contended that results of improvement were even more favourable to the objects of the author of the paper, than would be supposed from what had been stated, and adduced the facts of the gain by sanitary measures in towns. Reference being made to the branch of the subject connected with cottages in agricultural districts, Mr. C. H. Bracebridge described some cottages which he had built at Atherstone, Warwickshire, each containing equal to three bed-rooms, and which had cost, exclusive of closets at the back, but inclusive of a common wash-house and dust-bin to a group of five houses, as well as pathway, £81. 6*s.* per cottage. The object of low cost, and the provision of the third bed-room were attained by placing the bed-room in the roof—altogether, or nearly so. The roofs being constructed with queen-posts, the room was got in the space between the "queens." The area in the clear covered by each house was 21 feet by 13 feet: the room on the ground-floor was 13 feet square; and the space for stairs and other features of the plan, 13 feet by 8 feet, including the partition. The room in the roof which ran from end to end, was of adequate height, and it cost about £6 of the amount named as that for the whole cottage. This room was not, it was true a very good one; and it had to be reached by some kind of ladder; nevertheless it served the purpose, and it had an advantage over a better room, as it could not so well be let. Water supply, except that from the roof, is not included in the amount named.

EXAMINATIONS AND DIPLOMAS FOR THE ARCHITECTURAL PROFESSION.

In our number for April of the current year, the subject of examinations and diplomas for the architectural profession received a short notice, and the prospect of such examinations being proposed by the Institute of British Architects was announced. Since then the proposal, which at that time was under the consideration of the council of the Institute, has been submitted by them to the general body of members; and after being under discussion for two successive evenings, being the last meetings of the session, the subject was postponed until next session for further consideration. The representatives of the press were not admitted at the two meetings referred to, and therefore it would be opposing the tacitly expressed wish of the Institute were we to attempt to give any account of what is understood to have been the course of the discussion on those occasions. So much as has however been laid before the public may be repeated here without any impropriety, and that amounts simply to the announcement, that whereas the council of the Institute proposed as a resolution that it was desirable to afford an opportunity of voluntary examinations to the *present* associates and *future* Associates and Fellows of the Institute, the meeting after very considerable discussion carried an amendment, purporting that it was desirable to afford such an opportunity to the members of the profession generally; and after some further discussion the adjournment of the subject to next session was decided upon.

It cannot but be felt that the resolution enlarging the scope which the proposed examinations should take is an advantageous one, and that the more general they can become the more useful they may be expected to be. A difficulty cannot however fail to present itself the moment any sort of test is attempted to be proposed which men established in practice might undergo: they are actually in a position which they have made for themselves by their own exertions; many of them in as good an one as they can ever hope to get; and having nothing to gain from a diploma or certificate, or any other public proclamation of their proficiency, are naturally disinclined to take the trouble to undergo an examination.

There is too the feeling, that however well they might years

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ago have answered questions on many building matters, they have now been so long occupied in *doing* rather than describing, that they would find it difficult to meet an examiner successfully. Many of the ablest men, and those who have constructed the finest engineering and architectural works, have possessed little facility at putting their thoughts into words, easy as it might be practically to embody them. The late George Stephenson was a well known instance of this, and by no means an unusual instance. Such a man has perhaps not only nothing to gain, but something to lose by an examination.

Again, other parties object, and with justice, that they have not been trained or brought up under a system of examination: they have done what is necessary to insure success and practice in their profession as things now are. They have succeeded,—they do practice; and they ought not to be made to begin over again. Others too urge, and with still more reason, that the course of education of architects in this country is not, and has not been, one that embraces an examination as one of its objects, and that even the younger men are not fitted to pass anything like a searching examination in matters which in actual practice they could be depended upon to do correctly and safely. And for all these difficulties some remedy must be found, which necessity only requires to be an *interim* remedy, as a few years' custom would obviate nearly all the objections that can be raised under either of the heads just indicated.

That a voluntary examination open to all members of the profession should be successful, it appears essential that a very large proportion of those architects now in practice should be induced personally to sanction it, and in fact should procure for themselves the certificate of having passed it; but the considerations we have brought forward appear to present a difficulty in the way of procuring the personal adhesion of a large portion of the architects actually in practice. Several schemes might be devised for meeting this difficulty, for several methods might undoubtedly be followed in the examination which would not be unfair to the senior members of the profession,—which would on the contrary meet them on their own ground, and afford them a fair mode of showing their skill and competence.

The gist of these expedients would necessarily consist more or less in substituting an examination of productions for an examination of the producer. One scheme may be given as a specimen, and it is one that can hardly fail to have suggested itself to persons interested in the subject.

It might according to this plan be decided that a certificate bearing the same value, though perhaps not drawn up in the same form, might be awarded indifferently to the successful candidates in two entirely different sorts of examinations; it being at the option of the candidate in which form he will take his examination. The first to be the ordinary mode of written or oral examination, as practised for university degrees. The second mode to be by submitting to the examiners, without attending personally before them, the drawings for and accounts relating to buildings executed under the applicant's superintendence and from his design, under regulations something like the following: The buildings to be, say, five of which the aggregate cost was not less than £6000, or two of which the cost together was not less than £10,000, or one not under £15,000. All drawings, documents, working drawings, and information requisite for thoroughly understanding each building, and a photograph of it to show that it is genuine, to be furnished. A certificate, or at least a statement under the hand of the candidate, to show that it has bonâ fide been designed and carried out satisfactorily, to be appended. The examiners to have power to grant or refuse the certificate upon the examination of the plans only, or in any case of doubt to suspend granting the certificate till the candidate has appeared before them to answer any questions they may put to him.

This would form a test which any Fellow of the Institute, or any architect in good practice, could undergo without the smallest personal trouble. It would prove equally as well as any oral examination the competency of the candidate to act as architect to important works, because it would show that he *had* acted in that capacity. And lastly, if any improper person attempted in this way to pass the examination irregularly, or if any incompetence either in construction or in design appeared upon the face of the plans, or if the accounts showed marks of great irregularity or neglect, the power of calling the candidates before them would enable the examiners to satisfy themselves of his competency or ignorance, at least as well as they could have done without the previous examination of his plans.

It is needless to observe that such an arrangement is essentially temporary in its nature, and adapted to a transitional state of things, suited to render the possession of the Institute certificate a point of honour among architects; but if continued for more than four or five years it might be turned into a means of evading an examination, which by that time we hope will have become such as to require that a successful candidate shall be moderately well informed in all points connected with his profession, and accomplished in at least one.

A necessary consequence of the permanent establishment of any system of examinations must be the rise of a suitable provision for the education of youths, so as to enable them to pass. This, if not pushed to excess, might be of value; but there is a certain risk that those topics which are most easily taught by the professor, and upon which a student is most easily examined by a complete stranger, should usurp an undue importance. The history of architecture, to quote only a single specimen, is a subject upon which endless lectures could be given, and an endless series of questions put; and the art of designing mouldings is, on the other hand, one extremely difficult to teach, and not an easy theme for an examiner;—yet, it will be understood in a moment, that the youth who after a year's study in old buildings, or among casts and books, or upon new works, had acquired a skill at designing profiles suitable in size and outline to their intended positions, and the effect of which would harmonize with the style of any given building, has made a far greater stride towards an acquaintance with his profession, than one who could mention the earliest and latest dates at which any particular moulding could be found, and the principal instances in Great Britain in which it occurs. The one is certainly learning to be an architect; the other may or may not become an architect,—he has only shown himself an antiquarian.

Let the examinations however only remain *practical*, even after the provisional system we have suggested (or some substitute for it) has been done away with, and there will be little to fear from the preparatory course of lectures and studies; while an enlarged acquaintance with the literature of the art must necessarily lead to good results, if joined with studies practical in their nature and tendency. The system, once inaugurated, may fairly be expected to advance, and to improve the position in every way of this already flourishing profession.

ON THE APPLICATION OF ELECTRICITY TO THE LIGHTING OF GAS.*

By Arch. Wilson, New York.

To render the application of electricity to the lighting of gas practically a success, several things are required, the want of any one of which is sure sooner or later to disappoint both the experimenter and the public. The mode of application must be simple, easy to adjust, efficient, reliable, and economical. The method or plan that shall claim public patronage must combine all these requisites. Science seems to have demonstrated that electricity is susceptible of such an application but upon two general principles: one is by using the current to heat a platinum wire, the other to generate the electric spark. While it has been universally admitted that the latter would most fully furnish all the requisites for success if it could be applied, yet, with the exception of very limited experiments in the laboratory or lecture room, it has been as universally abandoned as impracticable for the following reasons, supposed to be insurmountable:—1. The current which generates the spark is of such extreme intensity, that it has been deemed impossible so to construct a long circuit as to protect or control the current for any great distance, owing to its tendency to fly off to surrounding objects. 2. The instruments heretofore used to generate the spark have been so extremely susceptible to atmospheric changes as to become entirely inoperative in a moist atmosphere. Hence experimenters in this direction have given their attention and skill almost exclusively to the application of the heated wire to this purpose. Still, the difficulties which attend this plan were so early presented, and so clearly brought out by the late Dr. Hare, of Philadelphia, that it would seem that the most unscientific experimenter must have been convinced of its impracticability beyond a very limited success.

* From the 'Journal of the Franklin Institute.'

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These difficulties are, first, the currrent used to heat the wire is a quantity current, and generated by a voltaic battery. Consequently the entire source of the power is constantly decreasing in efficiency, and wearing away under the action of the acids upon the metals used: frequent repairs therefore become necessary. Then, as the number of wires to be heated is increased—and there must be one of these wires over each burner—or the length of the circuit is extended, the source of the power must be increased also; till, where a large number of burners is used, and the current is to be passed through a long circuit, the battery becomes immensely increased, and the outlay to replenish it and keep it in repair is correspondingly large, as five hundred pairs of plates, other things being equal, wear out just as rapidly as five pairs do. Hence it becomes a very great desideratum, economically, to reduce the number and size of the plates as much as possible, and yet produce the desired result.

Other difficulties, quite as serious practically, are continually met with in the wires to be heated; the least variation between them, either in their length, thickness, or the quality of the metal, being sufficient to prevent the gas from being lighted, owing either to the fusion of some of the wires by the current, or the failure to heat others sufficiently. And then these wires, as one must be placed directly across the top of each burner, and stand permanently in the jet of burning gas, soon become incrusted with a thick coating of soot. In this condition, the action of the battery must be continued till both the wire and its coating of soot are heated to the point for igniting the gas; or if the battery has fallen below the power required to heat these, it fails altogether to light the gas. In either of these cases the room is unavoidably being rapidly filled with the escaping gas. The length of time required to coat these wires with soot will vary with the purity of the gas used. Another difficulty with such wires is, that though the battery-power might be sufficient to heat the wires, yet a gust of wind or a too strong pressure of gas striking them will often cool them down below the igniting point, and time must be given for the gust of wind to cease or the gas to be regulated to the proper pressure.

This plan of lighting gas by the heated platinum wire demands in all cases an absolutely unbroken metallic circuit. The least break in the circuit, though it amount to no more than the hundredth part of an inch, is amply sufficient to prevent all action in the battery, and to leave a room or street in total darkness till such break is repaired; and this break can be repaired only by searching through the entire length of the circuit, as this can give no sort of signal to inform the operator where the break may be found. Though this plan may be adjusted with the greatest exactness, and even so as to do the work, with the greatest care of the operator, for several days or weeks, yet in an instant, from some unaccountable variation in the action of the battery, a wire is fused and the circuit broken, thereby producing the most serious annoyance at the most important junctures.

The difficulties of this plan, so clearly brought out by Dr. Hare and others, have led all scientific experimenters to abandon the hope that it can ever be applied with any permanent and satisfactory result, and to base their expectations and hopes upon the use of the electric spark for this purpose, should an instrument not liable to change with atmospheric changes and of sufficient power ever be invented. The spark, as it results from great intensity in the current, and leaps through free air, does away at once with all necessity for preserving an unbroken metallic circuit, since its success in gas lighting depends upon a break over each burner; and also does away with the small platinum wires to be heated over each burner. It was not until the discovery of the spark from the induced current generated by an instrument which was in no sensible degree susceptible to atmospheric changes, that a current seemed to have been discovered that could be relied on permanently to do this work. It was an examination as to the reliability and efficiency of this current that led me to the conclusion that in it was contained all the power that the most enthusiastic experimenter in this direction could desire. It has been with this current mainly that my experiments have been made, and it is my application of this current to the lighting of gas that I desire to exhibit before you. Before making my experiments I will, with your permission, give a short explanation of my mode of applying this current. I think I shall be able to satisfy you that the number of burners to which I apply it will exhaust but a very small portion of the power which I have here. I have connected my insulators and wires with the ten burners of the room and with the fifty-six burners of the chandelier which I have suspended from the centre of the room. In order to save the power of my current and use it with the utmost efficiency, I insulate all the burners in the room, by placing between the burner and the gas-pipe two small pieces of some non-conducting material, in this case hard rubber, which bears a high degree of heat. The lower piece of rubber is furnished at one end with a female screw and fitted to the gas-pipe or fixture; the other end has a male screw and is fitted to the burner. Before putting the burner on, I slip over the male screw of the insulator a looped copper wire—in this case No. 24—and then another small piece of insulator; after which I screw on the burner. The looped wire is then bent over so that the end comes just outside the jet of gas and within an eighth or sixteenth of an inch from the top of the burner. I then connect a looped wire with a burner, or two looped wires and two burners in succession, till all are connected, and these with my instrument; when my circuit is complete, with each burner making part of the circuit. For the sake of showing the safety with which I can pass over even the smallest wire any amount of current which my battery and coil can generate, my circuit wire is in this case No. 36 uncovered copper wire. My connections are now complete, and by means of the insulators at each burner the current will be made to pass around on the top of the burners, and as the electricity leaps across the space from the looped wire to the burner, the spark will appear and ignite the gas with the rapidity of lightning.

The electro-motive power which I use is a voltaic battery, and Ritchie's improved inductive apparatus. My battery by itself, and when applied to the heating of platinum wire to show its efficiency, is barely sufficient to heat wire enough to light two burners. If applied to a short piece of my conducting wire, No. 36, it would instantly burn it off. When connected with my coil it will not heat the smallest platinum wire that I have been able to obtain, and will pass with perfect safety over the smallest conductor. And yet I think I shall be able to show you that this current from a battery so inefficient in itself, will, with the coil, ignite 500 or even 1000 jets instantaneously; thus increasing the battery power several hundredfold. By bringing the pointers at the poles of my coil within one inch and a quarter of each other, and allowing my wires to be connected with the chandelier, I think I shall show you that this current, rather than leap across a single space of free air one inch and a quarter long, will leap across fifty-six spaces on the chandelier whose aggregate distance is eight inches. I shall also show you that if I break the wire entirely away from one pole of the coil, I shall yet light a large proportion, if not all, of the jets on the chandelier. Or if a break accidentally occur anywhere along the circuit, the spark will at once notify where the break is by the smart cracking sound which it will give.

The coil, which is the main source of the efficiency of this plan, does not wear out, and needs no replenishing. The only part that does wear out and that can require expense to repair, is the very small battery which I use, which can scarcely require the outlay of a shilling per month to keep it in repair. The acid in my battery I have often reduced to 1 part to 24 or 30 of water, using Smee's battery. No variation in the battery endangers the circuit, and the whole arrangement is so simple that anybody can keep it in repair.

With five Smee's cups, plates 8 inches square, and a very weak acid, I have sent this current over 600 miles of telegraph wire, without the aid of a single cup of a relay battery, and obtained a spark 2½ inches long. So that, had I a wire connected with all the street lights of New York, and ending my instrument in Wall-street, I believe I could light the whole city from my office.

A gust of wind or high pressure of gas striking on this spark has no other effect than to increase its size, and thereby add to the certainty of igniting the gas.

The advantages of this method are then:—

1. It avoids the extreme care required in other plans to preserve an unbroken metallic circuit.

2. No degree of variation in the battery-power will endanger the conducting wires, though reduced to the smallest size.

3. The waste of the battery is reduced many hundredfold, and the expense of keeping in repair is proportionally decreased, while its efficiency is as greatly increased by connecting with the inductive apparatus.

4. If a break in the circuit occurs out of place, a large proportion of the jets will still be lighted, while a smart cracking sound

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will at once direct the operator to the place where the break may be found.

5. No pressure of gas or gust of wind can affect the efficiency of the spark to do its work.

6. The smallest spark is amply sufficient to ignite gas.

7. This current is readily controlled, as is proved by its passing over 600 miles of telegraph wire with ordinary insulation,—a length of circuit more than sufficient to reach every public light in the largest city in the Union.

8. It ensures great saving of gas, from the fact that rooms need not be lighted till the moment they are wanted.

9. By removing all necessity for the use of matches and torches about buildings it affords great security against fire.

10. The conducting wire may be passed through the most inflammable materials with perfect safety, as the current used will not heat the smallest wire.

11. Its simplicity enables anyone to operate and keep it in repair.

REVIEWS.

Country Cottages; a Series of Designs for an Improved Class of Dwellings for Agricultural Labourers. By JOHN VINCENT, Architect.—London: E. and F. N. Spon. 1860.

The most important portion of this work consists of a series of designs for country cottages of a more or less ornamental character, carefully worked, out with perspective views and detail drawings, and accompanied by descriptions and estimates. To these are prefixed an essay on the condition of agricultural labourers, and some practical remarks on cottage-building

The introductory essay, while touching upon questions which, if introduced at all, might have been more carefully investigated, inasmuch as their bearing on the dwellings of the poor is but very partially illustrated, brings out in a striking manner the necessity of provision being made for dwellings of a class suited to the very poorest. The rate of wages for labourers in upwards of ninety localities in various agricultural counties is given in a tabulated form, and is shown to vary in those cases from eight shillings per week to sixteen shillings, while one instance is referred to in the introduction where the wage is as low as seven shillings. To pay any rent whatever is all but an impossibility for peasants labouring under such a weight of poverty as these simple figures alone indicate. And yet they *must* be housed, and ought to be housed in dwellings where decency and propriety shall not be constantly and necessarily outraged, as is too often the case in the cottages of both the rural and urban poor. Proprietors of cottages in rural districts cannot however be expected, save in solitary instances, to put themselves to much expense in supplying this accommodation, unless indeed it can be shown them that they can obtain a moderate interest on their outlay.

The real problem to be solved then, is to produce a cottage good enough to form a suitable residence for a family, and yet cheap enough to induce farmers and others to lay out money in its erection, knowing that they shall get a moderate percentage. Anything more costly than this, although it may be better suited to the purposes of benevolent and wealthy persons who will build a few cottages on their estate without any idea of profit, will not benefit the bulk of the labouring poor. We are bound to confess that viewed from this point, which Mr. Vincent's own statistics and inquiries tend most clearly to indicate as the true one, this elegant book is no nearer success than most of the many works that have already appeared on the subject. Mr. Vincent's cheapest cottage is estimated by himself to cost £125 to build; if it were proposed to erect it in any one of the thirty-nine parishes enumerated on his list, where labourers' wages are under ten shillings per week, we presume it would be almost hopeless to expect more than eighteen pence per week, or £3. 18*s.* per annum—being, without making any deduction for repairs or loss of rent, at the rate of £3. 2*s.* 6*d.* per cent.; but as in some districts not more than one shilling a week is paid, the return in these cases would only just exceed two per cent. Until something more remunerative than this is proposed to them, the bulk of land-owners will refrain from investing money in cottage building.

We have felt it necessary to point out this defect in the book on account of the paramount social importance of the subject: but having done so it is an agreeable duty to turn to the manner in which the designs are prepared, admirably adapted as they are for all situations where a little superfluity in the way of ornament is admissible. The author has worked like a genuine artist, and without sacrificing simplicity has produced a variety of elevations, picturesque in outline and good in proportion; the plans too are carefully studied, and the details, of which several sheets are given, are all excellent, and in fact form perhaps the most valuable portion of the work. All these drawings are well executed. The perspective views are, like the geometrical drawings, in lithography, but in a different style and with a tint over them. They are however somewhat less satisfactory, and appear to have been over laboured.

The practical remarks are sound and valuable, and we would recommend all engaged in designing cottages to consult them, especially on the points of dryness, ventilation, water supply, and general construction. Mr. Vincent, however, makes one suggestion which perhaps may be objected to. He recommends that the ground-floor rooms should not have plaster ceilings, but that the joists and under-side of the floor boards should be shown. The objections to this are first, that the privacy of the bed-rooms is destroyed by it, as all sounds will be transmitted through such a floor; and secondly, that the advantage of being able, after a fever or other infectious disease has visited the house, to limewhite it all over, is lost, and a ready means of brightening and cleansing the rooms from time to time at a very small cost, becomes applicable to the walls only.

With these observations we cordially recommend the book, venturing only to express a hope that, should it reach a second edition, Mr. Vincent will add a few designs for good cottages to be built at a cost not exceeding £90 each, and if possible below £80. Such cottages are practicable and have been built, and are more urgently needed than any other for the very poor; though for a class of occupants one degree higher, few if any better models than Mr. Vincent's could be found.

On the Construction of Artillery, and other Vessels, to resist great Internal Pressure. By JAMES A. LONGRIDGE, M. Inst. C. E. (Excerpt Minutes of Proceedings of the Institution of Civil Engineers, vol. xix.) pp. 172. 1860.

THIS is the title of a paper read before the Institution of Civil Engineers by Mr. Longridge; it is intended to explain the nature and point out the advantages of the author's method of constructing tubes of extraordinary strength and power of resistance to internal pressure. The author had for some time been engaged on experiments with a view to construct a gun of such strength that it would be impossible to burst it by the force of gunpowder; he had tried one plan after another until at length he hit upon his present ingenious and novel one, of forming the barrel of a thin tube of metal bound about by coils of wire, applied in a state of tension; the tension being so regulated that the strain on the barrel should be uniform or nearly so throughout its mass, during the explosion of the heaviest charge with which it could be loaded. Captain Blakely and Mr. Mallet had simultaneously with Mr. Longridge been endeavouring to apply the same principle of initial inner compression and external tension, but they had sought to effect this by means of building up guns of concentric layers of metal shrunk by contraction during cooling or by the hydraulic press. But we will allow Mr. Longridge to speak for himself.

"According to Robins the ultimate strength of gunpowder was valued at 1000 atmospheres, or nearly 7 tons per square inch.

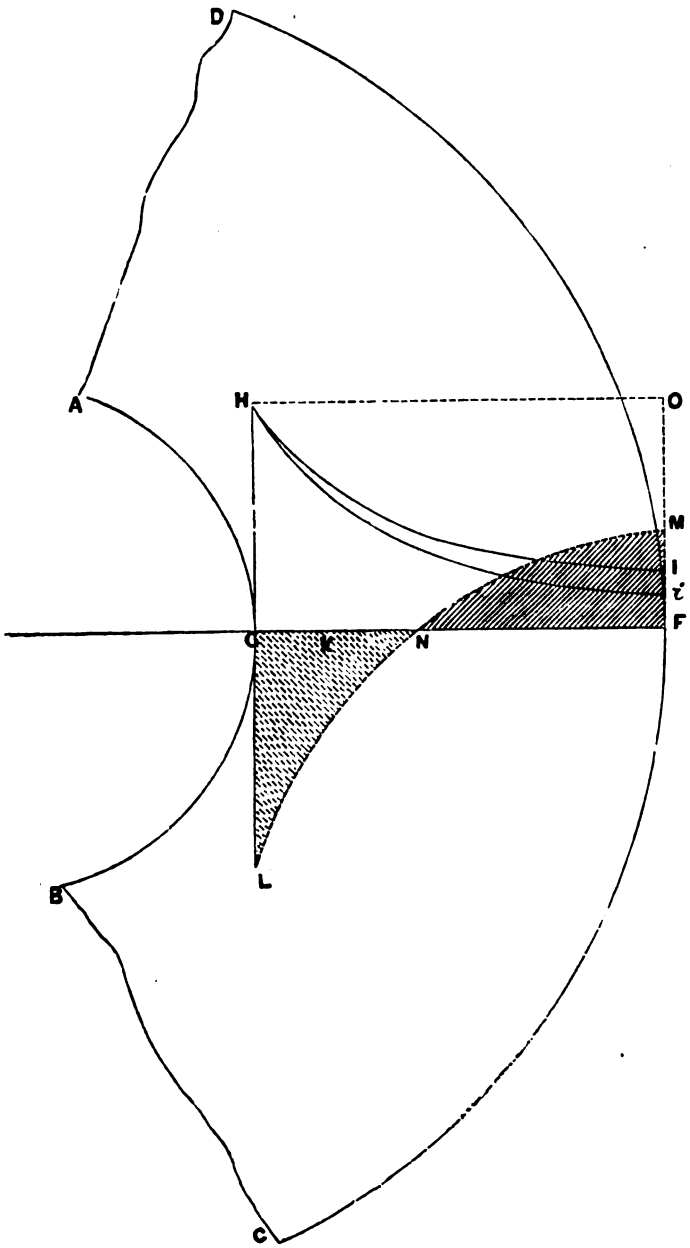
By Dr. Hutton it was carried as far as 2000 or 2400 atmospheres, or from 14 to 17 tons per square inch.

It seemed however desirable to the author to ascertain for himself this important point. It occurred to him, that the most satisfactory way of doing this was to prepare vessels of certain known strengths, then to fill them with powder, and having plugged them up so as to prevent escape, to fire the powder in the inside. He therefore made application for a quantity of government cannon powder, and had a series of thin cast-iron cylinders prepared, each 1 inch diameter, and $\frac{1}{10}$th inch thick. These were bored and turned, so as to be exactly of the same dimensions, and were purposely made of very hard and brittle iron, so as of themselves to give the minimum of strength. These cylinders were wrapped round with iron wire, the tensile strength of which was ascertained by actual experiment. The number of coils varied according to the degree of strength required, and each coil was laid on with the initial strain which the author's calculations led him to believe would, at the moment of bursting, cause all the coils to give way together.

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These cylinders were filled with powder and the end secured, leaving no vent beyond a touch-hole the size of a small pin, through which the powder was exploded. Several of these, of course, burst, but at length it was found that a cylinder, as above described, with ten coils of wire upon it, could not be burst.

Fig. 1.



Now the diametral section of the cast-iron is $\frac{8}{10}$ths of an inch, and taking its strength at 8 tons per square inch the result is,

	Tons.
$\frac{8}{10} \times 8$ tons per square inch =	1·6
There were ten coils of wire, each wire by experiment broke with 60 lb., and was $\frac{1}{32}$th inch in diameter, therefore the tensile strength of the two sides = $2 \times 28 \times 60 \times 10 \div 2240$ =	15·0
Total strength . .	16·6

The internal diameter of the cylinder was exactly one inch; consequently it appears that the ultimate strength of the powder did not exceed 17 tons per square inch.

The author would however wish it to be understood that he does not hold this to be the maximum effect that may be produced. The explosion of powder is more of an impact than a pressure; and although, strictly speaking, impact is only a pressure of short duration, the question of the length of this duration is generally admitted to have great influence upon the effect produced.

For instance, Prof. Rankine, in his 'Manual of Applied Mechanics' (p. 287) states, that 'a bar, to resist with safety the sudden application of a given pull, requires to have twice the strength that is necessary to resist the gradual application and steady action of the same pull.'

This being so, it follows that the more rapid the explosion, the greater is the strain on the gun. Not, probably, that the ultimate pressure is any greater, but that, being produced in less time, its effect is greater. This is probably the cause of guns being more liable to burst when they get hot. It is not that the iron is weaker, for Mr. Fairbairn has shown that up to 600° the strength of cast-iron is not materially diminished; but when the gun is heated, the gunpowder gets warm and burns more rapidly, and the force is generated and applied more suddenly.

Therefore, although the author found that the bursting effect of cannon powder did not exceed 17 tons per square inch, he is willing to admit that it may, under peculiar circumstances, exert a greater force. At any rate it seems to him that if it be sought to make the most of the force of gunpowder, the vessels in which it is employed should be capable of resisting at least this strain.

According to Prof. Barlow's theory, no vessel, however thick, can permanently resist an internal strain greater than the tensile strength of the material. This being so, and the tensile strength of cast-iron being about 8 tons per square inch, it is hopeless to look to that material for such strength as is required; and it does seem strange that the use of this material should be persisted in, and that experiment after experiment should be made in search of that which is as impossible to be found as the philosopher's stone, viz., a means to make cast-iron alone endure more than its ultimate strength."

After referring to the different kinds of guns at present in use or which have been proposed, and stating his objections to each one of them in detail, Mr. Longridge explains how his own is constructed, and what principles have guided him in the construction of it.

"The special requirement is, that each layer of the gun shall be in a definite initial state of tension or compression previous to the explosion. If (in Fig. 1) A B C D, represent a portion of a section of an 8-inch gun, of which A G B is the inner, and D F C, the outer circumference, the state of tension of any particle between G and F may be denoted by ordinates drawn at the points in question, those above G F representing tension, and those below compression.

If now the gun be of any homogeneous material, such as cast-iron, the state of tension at the time of explosion and when the gun is about to burst, will be denoted by a curve H I, or H i, the former calculated according to Professor Hart, and the latter according to Professor Barlow's formula. Then, supposing the tensile force of the material to be 12 tons per square inch, and the thickness of the gun 6¼ inches, when the strain at G is G H, or 12 tons, at F it is F I = 3 tons, or F i = 1⅞ tons, according as the one or other formula is adopted. The areas of these curves of course give the total strengths of the gun at the bursting point, and are found to be 36·72 tons and 30·871 tons respectively, instead of 78 tons, which it would have been if uniformly strained at 12 tons per square inch.

Now the object sought to be attained in the method of construction under consideration is, that each particle such as K shall, when explosion takes place, be equally strained with G. In order that this may be so, the initial state of the tension must be such as is represented by the curve L N W, those between G and N being in compression, while those between N and M are in tension.

If, now, it be attempted to accomplish this by means of hoops, it will be found impossible, inasmuch as each hoop is a homogeneous cylinder, and follows the same law throughout its thickness as is represented by the curve H I.

Figs. 2, 3, and 4, represent the successive states of stress of four rings, put on so as that when the explosion takes place they shall be all equally strained at their inner circumferences.

Fig. 2 shows two rings on
3 ,, three ,, ,,
4 ,, four ,, ,,

The figures denote the strains in tons per square inch.

From this it will be seen that when the four rings are put on, instead of the curve L N M of Fig 1, there are a series of abrupt changes, the two inner rings being in compression and the two outer in tension.

When the explosion takes place, the state of maximum strain is represented by the next diagram (Fig. 5).

The area between the dotted and full lines shows the work done by the explosion, and taking the total thickness of the gun, it amounts to 10·1 tons per inch of thickness; whereas had the construction been of very thin rings, or of small wire, it would have been represented by the area between the dotted line L N M O H (Fig. 1), and would have been = 12 tons per inch of thickness, showing a superiority of about 20 per cent. in favour of the wire over the hoops.

This is upon the supposition that the workmanship of the hoops is perfect, which in practice cannot be attained. To afford some idea of the accuracy required, the radii of the several rings shown in the above diagram are given in the following table:—

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No. of ring.	Inner radius.	Outer radius.	Thickness.	Differences.
1	4·0000	5·3222	1·3222	$R_1-\rho_2=\cdot0031$
2	5·3191	7·2928	1·9737	$R_2-\rho_3=\cdot0035$
3	7·2893	9·4633	2·1740	$R_3-\rho_4=\cdot0035$
4	9·4598	11·8237	2·3649	

Thus it appears that in order to give the requisite amount of initial stress, the external radius of the first ring must be $\frac{31}{10000}$ths of an inch, or about $\frac{1}{300}$th of an inch larger than the internal radius of the second: the external radii of the second and third $\frac{35}{10000}$ths of an inch greater than the internal radii of the rings next to them. Therefore, whilst the whole effect depends upon so small a quantity as about $\frac{1}{300}$th of an inch, it is evident that a very small error in workmanship will materially affect the result, and may tend to the most serious deviations from the proper initial strains.

This is a point of so much importance that the author has prepared

Fig. 2.

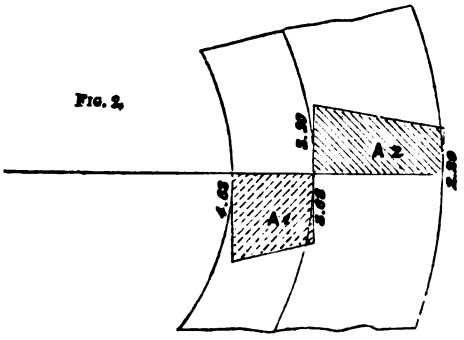


Fig. 3.

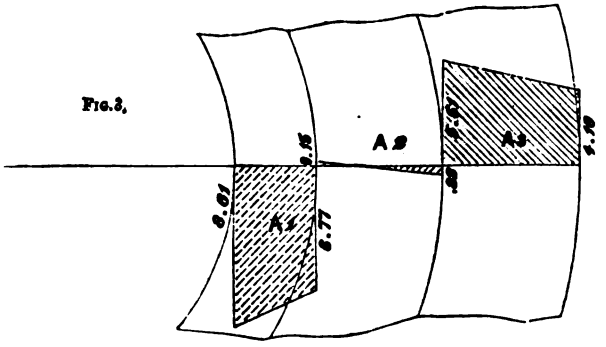
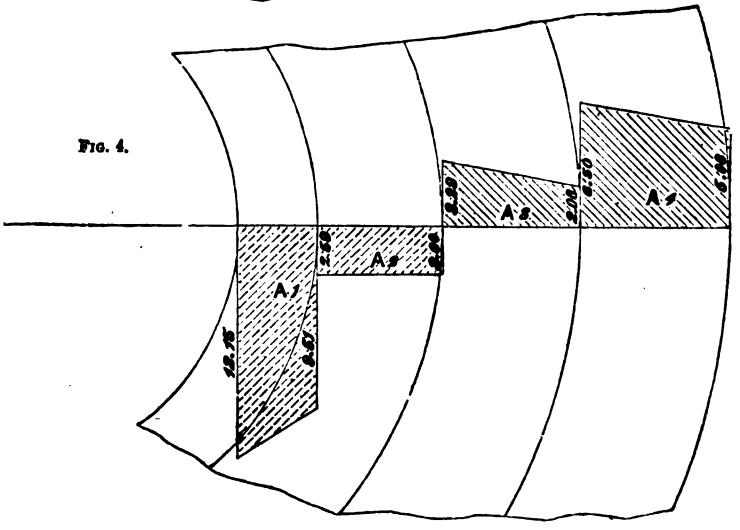


Fig. 4.



the following diagram (Figs. 6 and 7), to show the result of an error in workmanship of $\frac{1}{300}$th part of an inch in the size of the outer ring.

Fig. 6 represents the states of stress of the rings before explosion, and at the instant of maximum strain when the rings are accurately put on.

Fig. 7 represents the states of stress of the same gun when the outer ring has been made $\frac{1}{300}$th of an inch too small.

The result is, that before explosion, the maximum compression of the inner ring is increased from 10·086 tons to 11·244 tons, and the maximum tension of the outer ring from 5·778 tons to 7·823 tons per square inch; whilst at the time of maximum strain during explosion, the tension of the same ring is only 2·268 tons, although the outer ring is strained to 12 tons, its assumed ultimate strength. The absolute strength of the gun is thus reduced from an average of 10·5 tons to 6·0 tons per inch of thickness, or about 40 per cent., by an error of only $\frac{1}{300}$th of an inch in a ring of about 17 inches diameter.

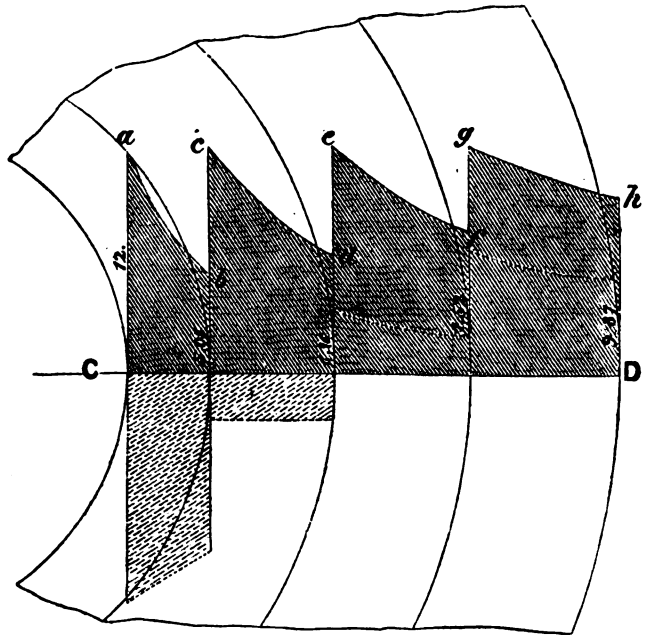
Rings, therefore, present practical difficulties which are entirely avoided by the use of wire, as it may be coiled on with the exact strain indicated by theory.

The method adopted by the author was to coil a quantity of wire on a drum, fixed with its axis parallel to that of a lathe on which the gun was placed. On the axis of this drum there was another drum, to which was applied a brake, similar in principle to Prony's dynamometric brake, so adjusted as to give the exact tension required for each successive coil of the wire. The whole apparatus was extremely simple, and the wire was laid on with great regularity. Indeed it is evident the apparatus might be so arranged, as that the process would proceed with the same ease and regularity as winding thread on to a bobbin, and at the same time with the greatest accuracy as regards the initial tension.

No such facility attends the use of hoops. They must be accurately bored, and after each layer is put on the gun must be placed in the lathe, and the hoops be turned on the outside. Great accuracy of workmanship is indispensable,—and not only is the amount of labour much greater, but it must be of a far higher and consequently of a more expensive class.

Then as to accuracy of tension with hoops. The author looks upon its attainment as almost impracticable. He is convinced that the process of shrinking on is not to be depended upon. Not only is there a difficulty of insuring the exact temperature required, but scarcely any two pieces of iron will shrink identically; and when the $\frac{1}{300}$th part of an inch of contraction would give rise to a great variation in tension, the necessity of perfect accuracy is apparent. But it has been proposed, and the author believes it is now solely advocated by Captain Blakely, that the hoops shall be forced on to a gun slightly conical, in longitudinal sections, by hydrostatic pressure.* Here again occurs the practical difficulty of the attainment of extreme accuracy of workmanship, involving the highest class of skilled labour, and the greatest vigilance of supervision."

Fig. 5.



The author having succeeded in fashioning some wire-girt tubes which resisted the utmost force of gunpowder, forwarded one of these to the Select Committee at Woolwich, for inspection and trial. The result of the only experiment made by the committee was however most unfortunate, not that the tube was burst, but the breech from an accidental defect (so pleads Mr. Longridge) was blown off, and the committee in consequence, politely—but, as it seems to us, rather too decidedly, and in a spirit not very remote from that of red-tapeism, too nearly resembling the dull negative conservatism of the Barnacle family, refused to have anything more to do with Mr. Longridge and his wire guns.

Such is the substance and drift of the paper read before the Institution, and from the animated discussion which ensued, and

* "In the course of the discussion it appeared that this is the method now adopted by Mr. Whitworth."

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the opinions expressed by the eminent practical men who joined in it, we are led to think that the wire system of gun-making, although hitherto not perfected into a practical reality, is yet valuable as containing a good idea, and which at all events deserved a more friendly recognition than it met with at the hands of the "constituted authorities." Among the savans present, and who took part in the conversation, were Sir W. Armstrong, Mr. Whitworth, Mr. Britten, &c., and Woolwich and the army were represented by Colonel Eardley-Wilmot, General Hay, General Burgoyne, &c. Colonel Wilmot, it is but fair to state, justified the rejection of Mr. Longridge's gun by the fact of the breech having been blown off by but a moderate proof charge; and

FIG. 6.

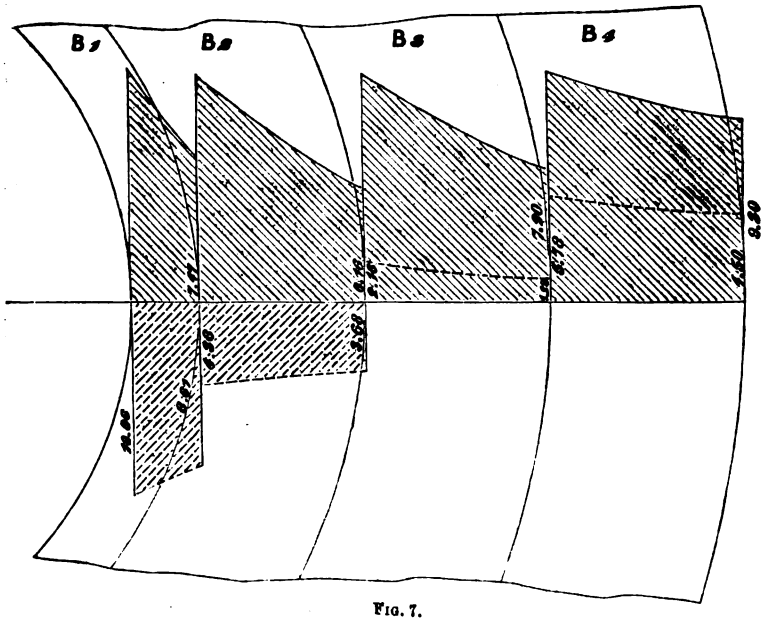
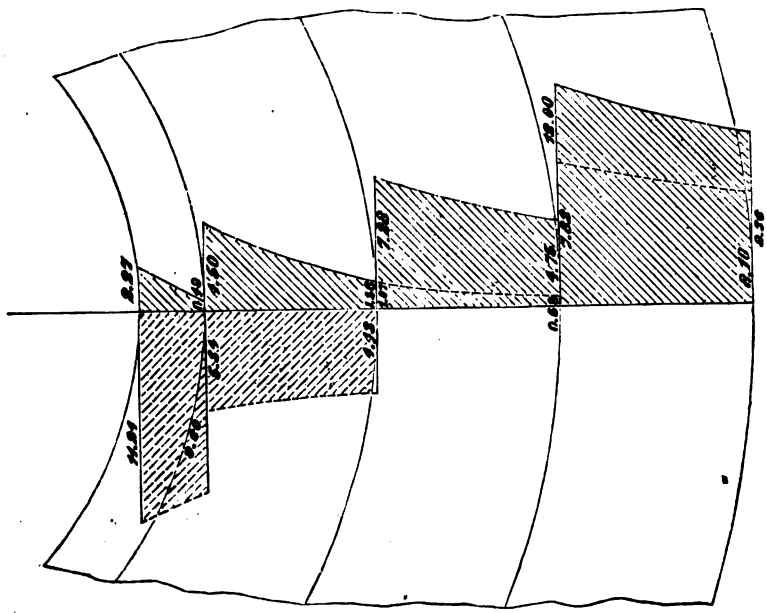


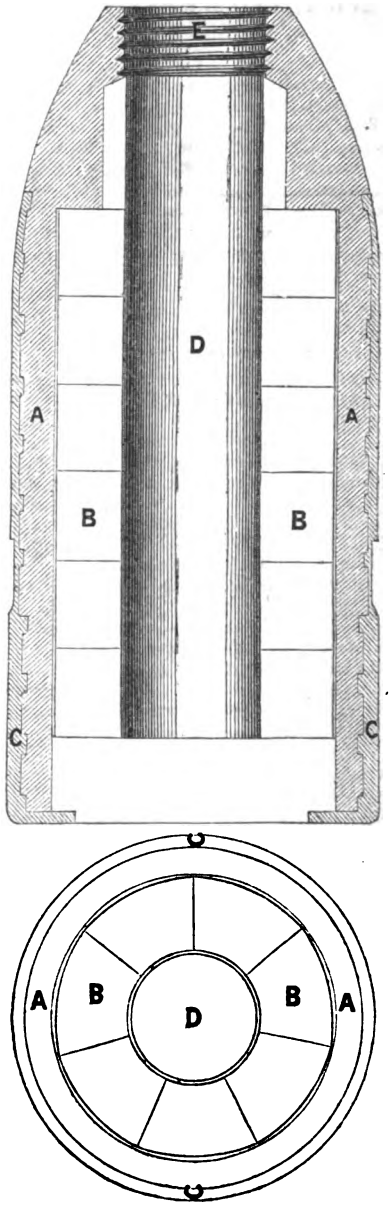
FIG. 7.



as the committee include such men as Professors Wheatstone, Sylvester, and Mr. Gregory, C.E., it is clear that no jealous feeling on the part of military towards civil engineers had anything to do with their determined rejection of Mr. Longridge's invention; besides, Colonel Wilmot freely admitted that the wire plan was good in many respects. We think however Mr. Longridge might have been allowed another trial. And here we may observe that what is new in Mr. Longridge's plan is, the regulated tension to which the wire is subjected. Cordage, or for aught we know, wire, has been used from time immemorial by the fire-work makers, in the construction of their pasteboard mortars for projecting the shells that explode in coloured stars; and the best gun-barrels are forged of thin strips of tenacious iron welded together, the strips being so narrow as to approximate to the condition of wire.

Opinions were much divided as to the degree of confidence to be reposed on rifled cast-iron guns. Mr. Britten, who has converted a great many of the old common guns into rifled ordnance, seems to think that with moderate charges they may be safely and usefully employed; a great deal will of course depend on the nature of the projectile, and the amount of turn in the rifling. We are inclined to be of the same opinion as Mr. Britten.

FIG. 8.



2-POUNDER SEGMENT SHELL.

A A, The Cast-iron Case, or Shell.
B B, The Segment Shot in layers.
C C, The Lead Covering.
D, The Central Cavity for Bursting-tube and Concussion Fuze.
E, Screw for Time Fuze.

Captain Boxer did not think with Mr. Longridge that civil engineers were so competent to deal with artillery questions as men who had been specially trained to that one pursuit. He proceeded to enunciate statements as to the theoretical action of gunpowder which we fancy would not be agreed to by Prof. Stokes, the greatest living authority on the theory of fluid motion, and to which statements we observe that Mr. Bidder also emphatically refused his assent.

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Sir Charles Fox did not think it was practicable to construct a gun which should when explosion took place, make available the whole thickness of the gun. He advocated the plan of casting guns of the densest alloys possible, and instanced the success of Mr. Mushet in obtaining an excellent alloy of iron and titanium.

Mr. A. Abel stated that one of the best materials was cast-steel, well worked; and an alloy of copper and phosphorus bore also a strain of 50,000 lb. to the square inch.

Mr. C. W. Siemens described the highly ingenious methods by which his brother sought to determine what the pressure upon the interior of a gun really was, and also what was the resistance of the atmosphere to shot. These methods are too long to be given in detail, and as they could not be rendered intelligible by any condensed description, we must refer the reader to the pamphlet itself.

Mr. Whitworth detailed the process of making his 80-pounder gun:

"The 80-pounder gun was purposely made so strong, that it could be submitted to any proof without injury. It was made of homogeneous iron. Upon a tube having an external taper of about one inch, a series of hoops, each about twenty inches long, were forced by hydraulic pressure. Experiments enabled him to determine accurately what amount of pressure each hoop would bear. All the hoops were put on with the greatest amount of pressure they would withstand, without being injured. A second series was forced over those first fixed, and thus the 80-pounder gun was constructed. At the present time it was not necessary to have the second series of hoops, but it was thought better, in the case of the first large rifled cannon, to have it stronger than was practically necessary; in fact, to make it so strong that gunpowder could not burst it. In the 12-pounder there were not any hoops at all, and Mr. Whitworth believed that a large-sized gun could be made with this homogeneous metal without hooping it. The inside of an 80-pounder gun was made of a tube of homogeneous metal; and the external rings were of fibrous iron, except two hoops next to the breech, which were made by Mr. Clay of puddled steel. The hoops were put on cold. The rifle twist in the 80-pounder gun was one turn in 100 inches; in the 12-pounder it was one turn in 60 inches; and in the small 3-pounder it was one turn in 40 inches. With respect to the degree of rifling adopted in the Whitworth guns, enabling the powder to be consumed more effectually, the following experiment was mentioned. Two barrels alike in diameter and bore were prepared; all the conditions were identical, except the difference of twist in the rifling. One barrel had two turns and the other had four turns. It was found, on placing them both at an elevation of 1° 20′, and firing them with 50 grains of powder, that they each carried the shot to about the same height on the target. Mr. Whitworth then fired them with an increased charge of powder, and the barrel with two turns sent the shot considerably higher upon the target, while the barrel with four turns sent its shot very little higher than with the small charge. A length of 10 inches was then cut off the latter barrel, leaving only three turns, and it was fired again with the increased charge. The result was, that the elevation remaining the same, it threw its shot higher on the target than the other barrel. This showed that rotation must bear a due proportion to the length of the barrel. It was desirable to have as much rotation as possible, taking into consideration the length of the gun. With a very long gun it was not advisable to have very rapid rotation, as the quick turn of the projectile was most felt at the muzzle."

This, if we understand it right, must be a faulty mode of construction; and so thinks Mr. Longridge, who in his reply observes of the way the hoops are put on, "Mr. Whitworth puts them on with great initial tension, in fact with the utmost the material could bear without a permanent set, and consequently the least increase of strain caused by the explosion would give them a permanent set."

Sir W. Armstrong's communication is so interesting that we give the first part of it in full.

"Sir W. Armstrong said, the subject of the present discussion was one upon which he had hitherto observed almost entire silence, and it was only because the public attention had recently been so vigorously roused in reference to competing systems of gunnery, that he was induced to deviate from that reserve which it would have been more consistent with his official position to have maintained. It was however a satisfaction to him, that owing to existing circumstances, the first distinct and detailed description of his rifled ordnance and projectiles would be communicated to an Institution composed of his professional brethren, and comprising so many persons with whom he had long been on terms of intimacy and friendship.

He had brought for inspection a specimen of his 12-pounder field-gun, in the exact form in which it had been recently introduced into Her Majesty's service. But before he proceeded to give a description of it he thought it would better conduce to a clear understanding of the gun, if he first directed his observations to the projectile; because he considered that in all cases the projectile should rule the gun, and not the gun the projectile. The projectile had to do the work, and it must evidently be the proper course, first to determine what kind of projectile was required, and then to devise the form of gun most suitable for throwing it.

It had hitherto been the practice to take into the field three kinds of projectiles, viz.:

1st Solid round shot;
2nd Shrapnel shell;
3rd Canister shot.

The first of these was, as its name implied, a simple solid sphere of cast-iron. The second was a shell containing leaden bullets, with a small bursting charge, and fitted with a time-fuze, ignited by the flash in the gun, so as to explode the shell a short distance in front of the object aimed at. The third consisted of a number of small iron balls, inclosed in a thin canister, and designed for firing on an enemy at very short distances. Both the round shot and the shell were very uncertain in their action, and could scarcely be used with effect at more than a thousand yards. But apart from the defects of all these projectiles, there was an obvious inconvenience in having three varieties to carry, because after exhausting the kind most suitable for any particular service, it became necessary to resort to a kind not adapted to the purpose. Sir W. Armstrong therefore conceived the idea of constructing a projectile which might be used at pleasure as solid shot, as shrapnel shell, or as canister shot; and which should also have the advantage of exploding by impact, as well as by the action of a time-fuze. Specimens of this projectile, both entire and broken open to show the interior, were exhibited (Fig. 8). The projectile consisted of a very thin cast-iron shell, the interior of which was composed of forty-two segment-shaped pieces of cast-iron, built up in layers around a cylindrical cavity in the centre, which contained the bursting charge and the concussion arrangement. The exterior of the shell was thinly coated with lead, which was supplied by placing the shell in a mould, and pouring melted lead around it. The lead was also allowed to percolate among the segments, so as to fill up the interstices, the central cavity being kept open by the insertion of a steel core. In this state the projectile was so compact that it might be fired through 6 feet of hard timber, without injury; while its resistance to a bursting force was so small, that less than one ounce of powder was sufficient to break it in pieces. When this projectile was to be used as a shot it required no preparation, but the expediency of using it any case otherwise than as a shell was much to be doubted. To make it available as a shell, the bursting tube, the concussion arrangement, and the time-fuze, were all to be inserted; the bursting tube entering first, and the time fuze being screwed in at the apex. If then the time-fuze were correctly adjusted, the shell would burst when it reached within a few yards of the object; or failing that, it would burst by the concussion arrangement when it struck the object or grazed the ground near it. Again, if it were to act as 'canister' upon an enemy close to the gun, the regulator of the time-fuze must be turned to zero on the scale, and the shell would then burst at the instant of quitting the gun. In every case the shell, on bursting, spread into a cloud of pieces, each having a forward velocity equal to that of the shell at the instant of fracture.

One of these shells had been burst in a closed chamber, where the pieces could be collected. It would be seen that they consisted of—

106 pieces of cast-iron; 99 pieces of lead; and 12 pieces of fuze, &c., making in all 217 pieces.

Now it was no uncommon thing for one of these shells to make 100 holes in a column of targets, at a distance of 3000 yards, and as a large proportion of the pieces was derived from the lead, it would be seen that the lead added greatly to the efficiency of the shell.

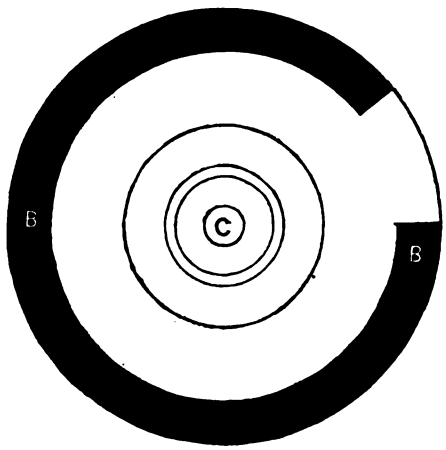
The time-fuze and the concussion arrangement demanded careful explanation.

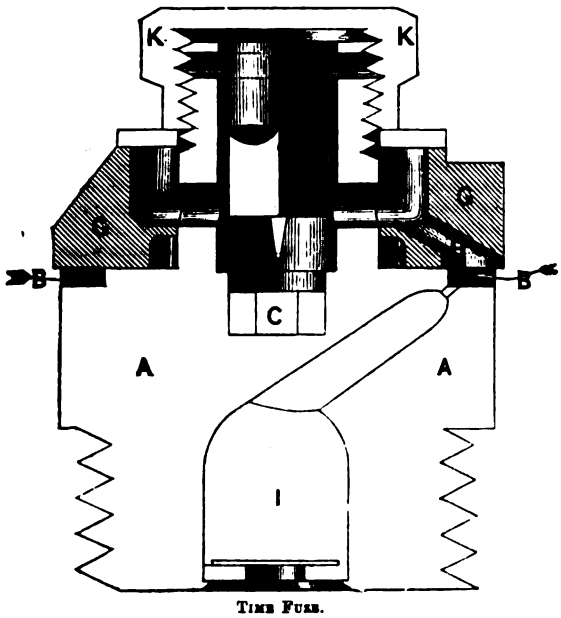
The body of the time-fuze (Fig. 9) was made of a mixture of lead and tin, cast to the required form in a mould. The fuze composition was stamped into a channel, forming nearly an entire circle round the body of the fuze, and was afterwards papered and varnished on the external surfaces. As the shell fitted accurately into the gun, there was no passage of flame by which the fuze could be ignited. That effect was therefore produced in the following manner. A small quantity of detonating composition was deposited at the bottom of the cylindrical cavity in the centre of the fuze, and above this was placed a small weight, or striker, terminating in a sharp point presented downward. This striker was secured in its place by a pin, which when the gun was fired was broken, by reason of the vis inertiæ of the striker. The detonator was then instantly pierced by the point, and was thus fired. The flame thus produced passed into an annular space, formed within the revolving cover which rested on the upper surface of the fuze composition, and from this annular space it was directed outwards, through an opening, so as to impinge on and to ignite the fuze composition at any required part of the circle. The fuze thus ignited burnt in both directions, but only took effect at one extremity, where it communicated with a small magazine of powder in the centre. The fuze was surrounded by a scale paper, graduated to accord with the elevation of the gun, so that when the range of a distant object was found by trial, it was only necessary to turn the igniting aperture of the cover to the point on the fuze scale corresponding with the degrees and minutes of elevation on the tangent

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scale. This fuze had the advantage of being capable of adjustment and re-adjustment any number of times before entering the gun, and the officer in command had the opportunity of seeing that it was correctly set at the moment of being used.

Fig. 9.





Time Fuze.

A A, The body of the fuze.
B B, Groove containing the fuze composition.
C, The detonator.
D, The striker.
E E, The holding pin.
F F, The flame passage.
G G, Revolving cover or regulator.
H, Igniting aperture.
I, Chamber for priming powder.
K K, Tightening cap.

The concussion fuze (Fig. 10) was on nearly the same principle. A striker with a point presented upwards, was secured in a tube by a wire fastening, which was broken on the firing of the gun; the striker being then liberated, receded through a small space, and rested at the bottom of the tube; but as soon as the shell met with any check in its motion the striker run forward and pierced the detonator in front, by which means the bursting charge was ignited."

Mr. W. B. Adams insisted on the advantage of placing the centre of gravity of the projectile forward; and he animadverted on the modern system of manufacturing gunpowder, by which it is rendered dangerously strong and quick-burning. We agree heartily with Mr. Adams in all this; but must remind him either that our ancestors' bows drew more than 60 lb., or that they had not a range of 600 yards. We believe that the stronger class of bows were of 120 to 150 lb. strength, and the range might probably have been 400 yards; but notwithstanding the exaggerated stories of the exploits of the archers of the "olden time," we do not believe that any one of them ever shot an arrow 600 yards.

We have not space to notice the remarks made by all the speakers. The summing up of Mr. Bidder was especially clear and comprehensive: we must give at full, at least, the first part of it; and we shall conclude this notice by a few remarks of our own.

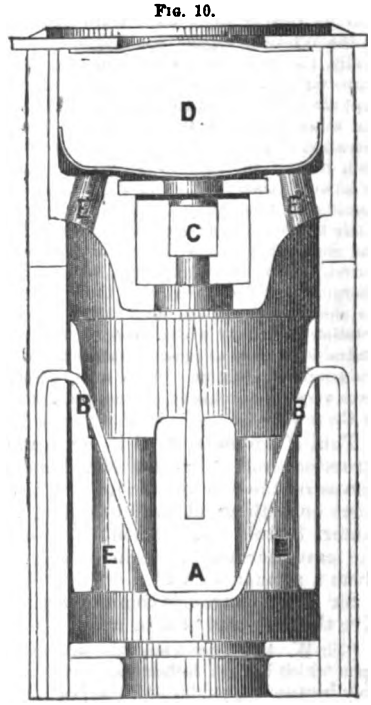
"Mr. G. P. Bidder (President) said, the Institution might take credit for the very interesting character of this discussion, which was one of national importance: in fact, it had fully justified the observation which he had made in his opening address on taking the chair,—that there was not any arena in this or any other country so well calculated for the discussion of this class of subjects as within the walls of the Institution of Civil Engineers.

The more immediate subject of the discussion was the capability of vessels to resist great internal pressure, as proposed in Mr. Longridge's paper. This had induced the question of the construction of guns, and the proposition to extend the range of the subject had led to the interesting discussion which had taken place.

It must be admitted, that the theory propounded by Mr. Longridge with regard to the tensile force of metal had been satisfactorily demonstrated; and theoretically the plan he proposed would appear to answer the intended purpose. Practical objections had however been fairly and legitimately urged against the proposed plan. These related chiefly to the difficulty of securing the ends of the wire, of strengthening the breech, and of forming the muzzle. How far Mr. Longridge had succeeded in meeting these difficulties the members must judge. It was however evident that Mr. Longridge had established such a *prima facie* case as should have entitled him to have received the attention of the government in his attempts to produce a light and efficient gun; especially when it was considered that the subject was only now for the first time undergoing that careful scientific investigation to which its great importance entitled it.

There had been exhibited to the meeting two guns of the most scientific design and beautiful workmanship,—the respective inventions of Sir W. Armstrong and of Mr. Whitworth. With regard to the manufacture of the former, the President could not coincide with the opinions expressed as to the difficulty of forging such guns. He had witnessed the operations, and as far as his experience went he must say that the mode of construction appeared to be most satisfactory; and he had no doubt that the guns so constructed in the new gun factory at Woolwich possessed all the characteristics claimed for them. At the same time, from the general tenor of the discussion, it was evident that there was a strong feeling in favour of the use of the homogeneous metal used in the manufacture of the Whitworth gun, and in that opinion the President participated. The metal certainly possessed the characteristics claimed for it: it was nearly as hard as steel, and as tough as copper; and as a material for artillery what more could be desired? Cast-iron guns had, no doubt, occasionally exhibited wonderful results. They had with stood an immense amount of firing and strain, but there was not any certainty of uniform results being obtained. In one case a cast-iron gun had sustained fifteen hundred or two thousand rounds,—whilst another gun, stated to have been cast from the same metal, and under precisely similar conditions, had not resisted for a single day. This was one grave objection; whilst the great weight of cast-iron guns must in the present day be a formidable objection to the use of that material, either for field guns or for naval armament. In the production of artillery the first cost ought not to be weighed against attaining the greatest efficiency, combined with the utmost saving of weight;—the latter he considered a point of primary importance. In the field it was imperative, both on account of the rapidity of manœuvring now required, and to facilitate the transport at considerable speed over a rough country; and on board vessels of war, carrying an armament of one hundred and forty guns, the saving of

Fig. 10.



Concussion Fuze.

A, The striker.
B B, The holding wire.
C, The detonator.
D, The chamber for priming powder.
E E, Flame passages.

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weight must evidently be of the most material consequence. The rifling of cast-iron guns might have been a very proper subject for consideration some twenty or thirty years ago, and no doubt blame must attach somewhere that it was only within the last few years that the rifling of ordnance had been seriously thought of, or had been practically tried.

In making a few remarks upon the practical results of trials, the President begged the members to receive the calculations which he should present, and the results which he should submit to them, as mere approximations. There had been communicated to him the results of an immense number of experiments in gunnery, and upon testing them he had found that to a great extent the results were not such as could entitle them to implicit reliance. He did not mean by this to say that apparent facts had been garbled or misrepresented; but circumstances which had attended the experiments, but which had been omitted, had influenced the results, and thus rendered them useless for the purposes of investigation. Circumstances had occurred which convinced the President that we had made very little progress in the science of gunnery; a few weeks ago he thought that he was on the eve of ascertaining some definite results; but he felt now, after more careful investigation, that far from being at all advanced in the science, the threshhold was only just reached, and that scarcely anything was really known of that important science. The very first thing in gunnery, but upon which the authorities were not agreed, was the initial pressure of gunpowder, and its *modus operandi* upon the shot. Upon that subject the most discordant opinions prevailed. What he meant by the initial pressure of gunpowder gas, was the pressure of the gases evolved on the explosion of gunpowder when confined within the actual space allotted for the gunpowder itself. That was what must be arrived at in order to make the calculations as to the effect produced, considering also the circumstances under which the powder was exploded. In the course of the discussion, Capt. Boxer, who occupied a high position in the Royal Arsenal at Woolwich, and who claimed to have considerable information relative to the explosion of gunpowder, and the requisite strength of materials to resist its force, stated that the forces of gunpowder gas were of two kinds—statical and percussive. Now from this proposition the President must distinctly beg to differ. Statically, one pound of gunpowder gas would not have more effect in generating velocity than a pound of butter:—and if it acted percussively it must destroy both the projectile and the gun.

In the work of Mr. Lynall Thomas* it was stated that gunpowder had some mysterious action; that before the gases acted upon the shot there was some kind of undulation or oscillation which by some means communicated an initial velocity to the shot, irrespective of their expansive action. Mr. Treadwell,† again, stated that the whole force of gunpowder was due to the inertia of the shot, or of any mass with which it was placed in contact, at the moment of explosion; and he moreover said that a large charge of gunpowder, if exploded in vacuo, would not burst a sheet of tissue-paper. From that position it was scarcely necessary to record an unconditional dissent. All the phenomena attending the explosion of gunpowder could be explained by simple mechanical effects."

Mr. Longridge has given formulæ for the tension of the elements of a gun-barrel, but he does not define the meaning of the symbols employed. These formulæ he states are based on the investigation of Prof. Barlow and Mr. Mallet: we have only seen that of Prof. Barlow, and we doubt much if, in the case of a very thick gun-barrel, it would give very accurate results. Prof. Barlow assumes that the density of the barrel is not changed by tension; we may also assume that the thickness of the barrel and not the density remains constant. In this case we obtain a very different result. Neither hypothesis is strictly true, but we are almost disposed to think that the latter gives results not much wider from the truth than the former. We shall determine the relation between the pressure and tension on both hypotheses, and leave the reader to judge between them. Of course the solution of the problem can be *exactly* effected by means of the partial differential equations for the internal equilibrium of a solid, provided they are integrable in this particular case, and provided we know the elastic constants; but it would be only in case of simpler methods failing that we should have recourse to such severe analysis.

Suppose O the centre of a section of a gun-barrel made by a plane perpendicular to its axis: the section is supposed circular. Let OAC, OAB, be two radii meeting the inner and outer rings of the section in A B, C D, respectively, and including an elementary small angle $\delta\theta$. Let r be the radius of the inner section, r' of the outer one. Let P, P', p, p', be a small elementary arc, whose length is $(r+x)\delta\theta$, and breadth δx, at distance $x+r$ from O.

Now, if μ be the elastic constant and p the unit pressure on AB, and h be the small extension of r owing to p, the tension at AB will $= \frac{\mu h}{r}$; the tension at p will be $\frac{\mu h}{r+x}$; and since the moment of all the tension and external pressure about the centre of AB is zero, the resultant reactions along CA and BD, arising from the connection of that element with its neighbours, will also be zero. Hence

$$xp = \int_{r'-r}^{0} \frac{\mu h}{r+x} = \mu h \log e \frac{r'}{r}$$

But $\frac{\mu h}{r} = \mathrm{T} =$ tension at AB $\therefore\ p = \mathrm{T} \cdot \log e \frac{r'}{r}$

If, on the other hand, we assume that the density is constant, it is clear that the area of the annular section included between r and $r+x$ will be constant, however much r may vary, or x. If therefore Δ be the increment of $r+x$, corresponding to a small increment h of r, $\Delta(r+x) - hr = 0$ in the limit, because $\pi(r+x)^2 - \pi(r)^2$ is a constant. Hence

$$rp = \mu \int_{r'-r}^{0} \frac{\Delta\delta x}{r+x} = \mu \int \frac{hr\delta x}{(r+x)^2} = \frac{\mu h}{r}\ r'\left(\frac{1}{r} - \frac{1}{r'}\right)$$

$$\therefore\ p = \mathrm{T}r\left(\frac{1}{r} = \frac{1}{r'}\right) \quad \ldots\ldots \text{Barlow's formula.}$$

This formula we do not think would be very approximate if $r' - r$ were considerable;—further experiments are wanting on the resisting power of cylinders to internal strains. On the first hypothesis, in order that T may not be greater than p, $\frac{r'}{r}$ must not be less than e, the base of the Napierian logarithms, or 2·7 nearly; on the second r' must be infinite. Perhaps an additional term might be introduced into the expression for the tension, to account, so to speak, for the force which must be exerted in squeezing out each successive element. For if δx be the value of δx, when $r+x$ has its primitive value, $d(\delta x)$ the small increment of δx for a change Δ in $r+x$, since $(r+x)\delta x$ must always be constant, $\therefore\ (r+x)d \cdot \delta x + \Delta\delta x = 0$.

Now if this additional force be assumed proportional to the amount of compression—which seems likely enough—it may be put $\mathrm{C}(r+x)\delta\theta \cdot \frac{d \cdot \delta x}{\delta x} = \mathrm{C}\Delta \cdot \delta\theta$. Hence

$$rp = \mu \int \frac{hr\delta x}{(r+x)^2} + \mathrm{C} \int_{x} \frac{hr}{r+x}$$

But we should almost be inclined to doubt if Hooke's law would express the force of tension or so much of the force of tension as is due to mere displacement without change of volume; it seems to us, that this last term $\int \frac{\mathrm{C}hrdx}{r+x}$ would be more likely to measure the *whole* resistance to displacement; and that the term $\mathrm{T} = \frac{\mu h}{r}$ is more probably due to the absolute change of volume. We should like to know what would be the result of experiment on this point, but it would not be easy to measure the small variations in density of a solid subjected to tension. Of course, if our supposition be correct, Prof. Barlow's method of finding the internal strain is not to be relied upon; and the problem would be one of extreme difficulty, unless we adopted the opposite hypothesis, that there is no relative normal displacement,—no diminution of the thickness of the barrel, which is probably also quite untrue. We may perhaps at some future time return to the consideration of the problem of a strained barrel, but it must be when we have more leisure to ponder over the conditions of the question.

It seems to us that a serious objection to all systems of gun construction, depending upon initial strain, has been overlooked; and that is, that the toughness of the material will be liable to be continually lessened, owing to the tendency of the fibre to degenerate into facets. It is well known that a wire suspended for any length of time with a heavy weight attached to it loses its tenacity, and we are afraid that something of the same sort might take place in strained gun-metal. This would indeed be a fatal objection: we should prefer to make the guns clumsily thick even at the breech, rather than run such a risk; at any rate, guns

* 'Rifled Ordnance; a practical treatise on the application of the Rifle to Guns and Mortars,' &c. By Lynall Thomas. London, 1859.

† 'On the practicability of constructing Cannon of Great Calibre,' &c. By D. Treadwell. Cambridge, 1856.

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constructed on this principle ought to be tested from time to time, otherwise the lives of those who work them will be continually exposed to risk. With regard to the gunpowder in use at the present day, from the testimony of most writers, it seems to be far stronger than that formerly used; we think that a slower-burning powder, if the charge were increased in proportion, would produce the same effect as a quick strong powder, and with less injury to the gun. But there may be practical objections to that: it may not be easy to find such a composition as shall burn slower than that we have now, and which at the same time shall not leave more residue behind.

We confess, that as far as we can form an opinion from the rather conflicting evidence submitted to us, we should prefer Sir W. Armstrong's method of *building up* the gun, and would rather not expose the metal to a permanent strain. At all events, the government seems to have adopted the wisest plan it could, in availing itself of the services of scientific men who can suggest ideas, and of practical men to work out those ideas. The civil engineer can unite his practical knowledge of the strength of materials to the artillery officer's knowledge of the practical requirements of the gun and its carriage; and the mathematician can point out the nature of the strains and tensions, and roughly in some cases estimate them. In conclusion, we cordially recommend all those interested in the science of gunnery to obtain this pamphlet. We have endeavoured to give a sketchy outline of its contents, but it would far exceed our limits to touch even lightly upon all that is valuable in Mr. Longridge's paper, and still more so in the interesting discussion to which it gave rise.

THE NEW FOREIGN OFFICE.

'CLASSIC or Pseudo-Gothic,' and 'Shall the New Foreign Office be Classic or Gothic?' are the titles of the two most recent pamphlets on the great architectural question of the day. The former is issued anonymously, in reply to a *brochure* (also anonymous) called 'Shall Gothic Architecture be Denied Fair Play?' and the latter is a plea for *Gothic*, addressed to the members of the House of Commons, by Sir Francis Scott, Bart., Chairman of the Government School of Art, Birmingham. Both are written with ability, and place the contrasting recommendations of the two styles in a readily appreciable light; yet both are tinged with a degree of acerbity which rather militates against the success of the cause they respectively espouse. The Classic champion, especially, seizing upon a phrase "zealous men," employed by a former antagonistic writer, makes it almost the burden of his theme, under the guise of discussing "Christian," "Pagan," and "National" architecture; charging his opponent with having either misunderstood or misrepresented the nature of his remarks on the use of those words, as well as his exposure of the true character of the middle ages, more particularly as exemplified in its architecture:—

"Now the drift of our argument was, not that Gothic was to be rejected on account of the vices and barbarism of the middle ages, but that the virtues of those times were not a reason for adopting it; such a line of argument having been called for by the attempts made to bolster up the cause of the Gothic revival, by associating it with certain mediæval events, which, as in the case of the epithets 'Christian' and 'National,' were calculated to raise a prejudice in its favour, and to so depreciate the age of the Italian revival as to excite a prejudice against that style in a way corresponding to the misuse of the word 'Pagan.'"

In the opinion of our author the Gothic revival is mainly to be attributed to an undue admiration and illusive views, derived from poetry and romance, of the virtues of these "middle ages;" and he corroborates an opinion promulgated by Mr. Bell in one of his lectures, that the Gothic style, even taken at its best, is less favourable to a development of the highest art than the Classic styles. Viewed in connection with this, what shall be said to the following "note"?—

"A friend (not our zealous friend) has suggested to us that the observation, in p. 16 of the 'Remarks,' on 'the solemn grandeur of Gothic architecture as favourable to devotional feeling, seems to imply that less devotional feeling is experienced in Italian churches. We take this opportunity of saying that we had no such meaning, and that in thus speaking of Gothic architecture we had cathedrals only in view, not churches generally."

This statement has been well met by the inquiry whether "Bangor Cathedral is preferable to Beverley, or St. Asaph to St. Alban's;" for these are, strictly speaking, fair comparisons. Again, in page 18:—"We may take it for granted, from its prevalence, that the square-headed or slightly-arched window, of a certain width, and devoid of mullions and tracery, is the most generally convenient form that can be devised."

"We may take it for granted, from its prevalence, that the square-headed or slightly-arched window, of a certain width, and devoid of mullions and tracery, is the most generally convenient form that can be devised."

Here general convenience is certainly opposed to general practice, for the division (Gothicé *mullion*) must inevitably occur in large openings, with this difference, that whereas in Classic work its existence is as far as possible negatived, in Gothic its use is obviously shown, and engrafted as part and parcel of the general design. Once more:—"Classic with all its faults is still the style of the present day. It harmonises with all its indigenous productions, with its ordinary dwelling-houses, with its streets, . . . with everything, in short, in which adaptation to ends and economy of means are consulted. It is consistent with refinement, elegance, and convenience. No effort or contrivance is necessary to secure this consistency." How strangely this reads, for these are precisely the qualities so often urged in favour of *Gothic* architecture; which finds a warm advocate in Sir F. Scott, whose chapters are headed "Gothic the national style;" "Gothic the style of liberty and economy;" "The lineage of our Domestic Gothic is also purely national," &c.; and who makes good his points by several novel as well as apposite illustrations. The writer has evidently sought to infuse a dashing, sparkling character into his little book, and has in this succeeded: we could, however, have wished he had not been so flippant with his pen, or made so free with vulgar—not to say slang—epithets. As a specimen of his style, we may instance the following:—

"And what is Classic Architecture in England? As unprincipled as the Stuarts who brought it in, it is neither at unity with itself nor has it any power of development. Its construction is one thing; its ornament another. Baker-street and Wimpole-street are specimens of the one; of the other—their name is Legion.

There is the magnificent 'Carlton,' beautiful in itself, (and thankful one is for the polished granite,) but you might take a Brobdignagian razor and shave every column and entablature from the wall for all that they have to do with the construction of the building. It is the old Græco-Roman system over again, superbly struggling, yet in vain, to accommodate itself satisfactorily to the necessities of 'fenestration.'

Then there is the 'Rag!' the elevation of the ground-floor is an excellent bit of common sense, barring the mezzanines; while the upper story is a cramped and poor repetition of Palazzo Rezzonico—itself a barocco work, or of Sansovino's Palazzo Cornaro della cà grande—at Venice. And the frieze above! the most expensive and ludicrous piece of stone-cutting that even Anglo-Classicism has been guilty of. Fortunately it is so high that no one can study it but the War-office housemaids! There are little boys riding on sea-horses, festoons of flowers hung all about, here and there gigantic roses as big as soup-plates, mer-men blowing trumpets, and their fishy tails making 'confusion worse confounded;' however, as Lord Palmerston, who takes *omne ignotum pro magnifico*, says it is fine, let's pass on and say no more about it. But it is when one looks at the last Neo-Classic production in clubs that one hopes the worst is past; and that undoubted worst is the ground-floor vagary in the Charles-street front of the 'Junior United,' and the unsurpassably hideous lines of the great window in the Regent-street front.

After this exhibition one can even walk with calmness through Albertopolis and surprise the grey-brick houses dressing up in cement and pasting on their cornices.

As for interiors, the white wilderness of stucco that enlivens (?) the 'Rag' is a lesson indeed; while the iron-work of its staircase would disgrace a granary."

So much, then, for Classic *versus* Gothic! But, after all, the decision on the pending question rests at present with the Premier, who is professedly an uncompromising "Italian" in such matters. Whether it be wise for the dictum of one individual to have this overwhelming influence is not for us to decide; but a host of reflections immediately present themselves in contravention of such a proceeding. It remains to be seen whether the profession at large will bestir themselves yet again in endeavouring to secure a Gothic selection, and thereby endorse the choice which dictated the present Houses of Parliament, which, with all their faults (and these are neither few nor small), form by far the noblest and most characteristic edifice of modern days. We may confidently expect, moreover, that the new Foreign Office, if carried out according to Mr. Scott's favourite plan, while in harmony with the style of the Abbey and Houses of Parliament, will offer its own characteristic peculiarities; and these the special facilities of the style will turn to good account in admitting, to the most perfect extent, its adaptation throughout to the requirements of such a building, both externally and within.

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COOMBE CLIFF HOUSE, CROYDON, SURREY.

(With an Engraving.)

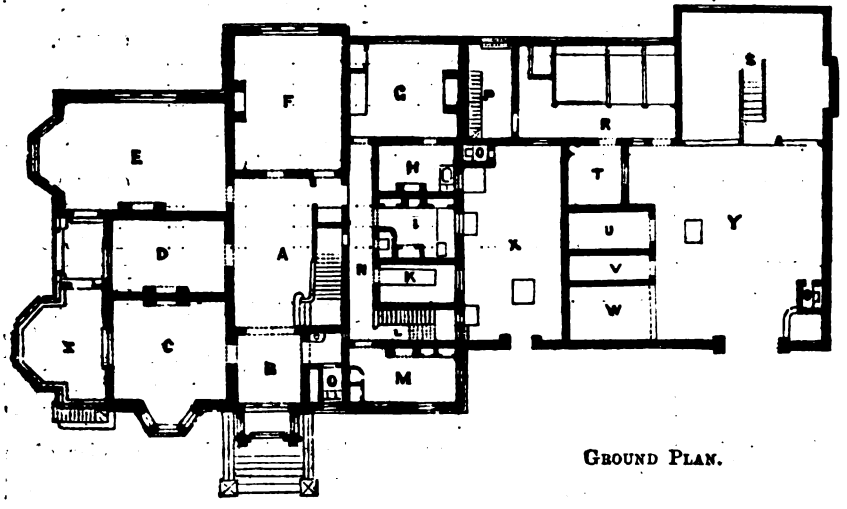
The perspective view of this villa given in the accompanying illustration is taken from the south-east, showing the lawn front, with the entrance to house and stables. The site, a very beautiful one, commanding extensive views, adjoins the Brighton Railway on its eastern bank, near Coombe-lane bridge, and is about 80 feet above the level of the line. The summit of the hill has been lowered 10 feet, excepting on the north side; the bank thus left is planted with evergreens, and provides a shelter from the north wind. The earth removed being thrown down to the southern side of the hill, the area of the lawn is extended at the level of 50 feet above Coombe-lane; the building stands upon a terrace 3 feet higher. The lowermost story of the tower forms a vestibule to the hall, which is 28 feet long by 17 ft. 6 in. wide, and contains the principal staircase; at the opposite end of the hall is the dining-room. On the left of the hall are arranged the drawing-room, library, and breakfast-room, each of which has an entrance into the conservatory, which is a prominent and ornamental feature in the design. The best bed-rooms and dressing-rooms and bath-room are over these principal apartments; and all open into the spacious landing and principal staircase, which is lighted by a central ceiling-light. The kitchen offices, back stairs, and corridor are on the right of the hall, the servants' bedrooms being over them. The servants' entrance is through the kitchen yard, beyond which are the stable offices.

The principal rooms on the ground-floor are ventilated by external fresh air tubes and gratings provided for each fireplace, with vitiated air-flues formed of cast-iron plates 12 inches high by 4½ inches apart, and fixed between the smoke-flues instead of the usual solid half-brick divisions. Valves are set in same at the upper part of the rooms, and other appliances are adopted in accordance with the recently patented system of Mr. Boyd. Perforated cornices to all the bedrooms allow of the escape of foul air into the roof.

The building is faced with Farnham bricks of a pale yellow tint. The Bath stone-dressings at first contemplated have been superseded by Portland cement, except in the shafts and carved caps of the first-floor window piers. The columns in tower openings are in Portland stone. The tower is 60 feet high and 130 feet above the level of the roadway.

At the entrance to the grounds are an elegant lodge and handsome recessed carriage gates and piers. The general arrangement of the grounds and roads was settled by the architect and the proprietor; the remaining portions of the earthwork and planting have been laid out by Mr. Darbyshire, the landscape gardener.

The total cost is nearly £8000, of which sum the house represents £5000. The architect is Mr. E. C. Robins, of Arundel-street, Strand, London, who is superintending the structure. The builders are Messrs. Jackson and Shaw. Mr. Harrison, of Manchester, is clerk of works for the proprietor, J. Horniman, Esq., and Mr. Winter for the contractors.



GROUND PLAN.

References to Ground Plan.

A. Hall and staircase.	O. Water-closets and lavatory.
B. Vestibule.	P. Tool and root house.
C. Breakfast-room.	Q. Straw, &c.
D. Library.	R. Stable.
E. Drawing-room.	S. Double coach-house.
F. Dining-room.	T. Harness room.
G. Kitchen.	U. Cowhouse.
H. Scullery.	V. Fowls.
I. Butler's pantry.	W. Cart shed.
K. Larder.	X. Kitchen yard.
L. Back stairs.	Y. Stable yard.
M. Housekeeper's room.	Z. Conservatory.
N. Kitchen corridor.	

NEW AGRICULTURAL HALL, ISLINGTON.

A structure on a somewhat large scale, illustrative of iron and glass architecture, is about to be erected at Islington. The accommodation afforded for agricultural and cattle shows at the Baker-street Bazaar has long been found quite inadequate for the required purposes, in consequence of which the Smithfield Club has determined not to renew its term of occupation there. Accordingly at the general meeting of the society in December 1858, a committee was appointed to inquire into the subject of how the requirements of the club could best be supplied. After carefully considering several propositions the members came to the conclusion that not one of the various suggestions then made was so well suited to the purpose as one which was subsequently obtained, and which the promoters of the Agricultural Hall Company are now about to erect.

The site lies between the eastern side of Islington-green, near the toll-gate and Liverpool-street, and will occupy an area upwards of three acres in extent, affording ample space not only for the present requirements of the club, but admitting of the extension of the buildings when required.

The new edifice will contain for the purposes of the annual cattle show more than twice the space at present afforded by the Baker-street premises, with the addition of committee-rooms, offices, salesmens' room, a house for resident manager, and refreshment rooms, the want of which has always been much felt by the visitors at Baker-street. When not required for the purposes of the cattle or agricultural shows, it is proposed that the great hall of the establishment should be used for poultry or flower shows and other exhibitions.

We have been favoured with a sight of the plans and sections of the new edifice, which is designed by Mr. John Johnson, architect, of John-street, Adelphi; and also of a model to scale, admirably executed by Mr. Samuel Salter, Hammersmith. The main building in the clear will be 292 feet long by 221 feet wide; in addition to which there is a separate structure 112 feet by 75 feet, fitted up expressly for the porcine race of animals. The principal entrance from Islington-green will be for foot passengers only; a corridor from this entrance communicating with the main building, will be furnished with stands for flowers, forming an elegant introduction to the structure.

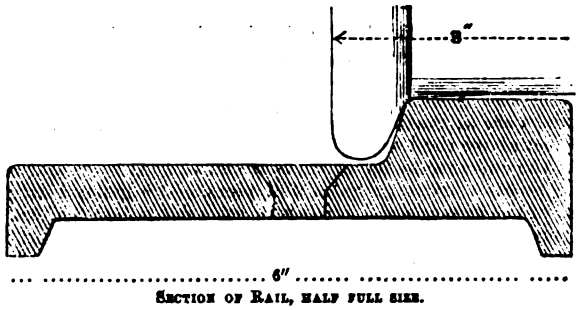
Like the Exhibition building of 1851, and that at Sydenham, the general skeleton will be in framed ironwork, the roof as usual being supported by a series of iron columns; the usual hip-and-valley construction being adopted for the roof. Transversely the internal area will be divided into three avenues, the two sides being 40 feet each in width, the central one, which is 70 feet wide, having a portico of ornamental character. Around the two sides and one end there will be galleries 35 feet in width, for the display of agricultural implements. First and second class refreshment and waiting-rooms are provided.

Great credit is due to the directors for the energy of their proceedings, and also to their architect for the ability displayed in adapting his designs to the peculiarities of the site and the special requirements of so large an undertaking.

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THE STREET RAILWAY, BIRKENHEAD.

In another part of our Journal for this month (p. 230) we have given an abridged report of the paper on Street Railways, read by Mr. Train before the British Association. We now add a diagram exhibiting Mr. Train's mode of construction of the tramway adopted by the Street Railway Company at Birkenhead for the tram now being laid down there.



Section of Rail, half full size.

The rail is of rolled iron in 24-feet lengths, the flat portion being $\frac{5}{16}$-inch thick, and the thickest part $1\frac{3}{16}$ inch. The rail weighs 50 lb. per yard, and is fastened to the longitudinal sleepers by wrought-iron spikes at intervals of 2 feet; the rails are united by joint plates, having wrought-iron spikes driven through them and the rail and into the longitudinal sleepers.



Cross-section of Street Railway, Birkenhead.
A. Oak trenail.

The wheels of the carriages are of wrought-iron, the tires being conical as in ordinary cases. The logitudinal sleepers are 6 inches by 8 inches, secured by oak trenails and cast-iron brackets to the transverse sleepers, which latter are 6 inches by 4 inches, and are placed 4 feet apart.

The flat portion of the rail (which is 4½ inches wide) is intended for the use of the ordinary street traffic, with which the tramway will in no way interfere, but greatly facilitate by classifying it. All the carriages will be provided with powerful breaks, so that no danger to ordinary vehicles on the tram is likely to arise. The road on which the tram is being laid at Birkenhead is macadamised, but for the purpose of tramways generally, pitching would be preferable.

THE VICTORIA BRIDGE, MONTREAL.

(With Engravings.)

A general notice of this great structure was given in our number for June last, page 157, with an engraving, Plate 14, showing on a large scale the details of the tubular beam of the central opening. In our last number were inserted engraved details (in Plates 16, 17, 18, and 19) of the tube adjoining each abutment:—Plate 16 showing the bearings on the abutments; Plate 17, a half-section at the bearing and at the centre of the tube; Plate 18, part plan of the bearings, with rollers and without them; and Plate 19, plan and section of roller-plates with other particulars. We now propose to go through some of the details of the construction of this great work which have been placed at our disposal.

The enormous breadth of the river, the vast body of water passing, and the packing of the ice when breaking up, formed in reality the sum of the difficulties to be contended against in an engineering point of view.

Foundations.—The bed of the river having been ascertained to be rock, generally covered with about 8 feet of clay or gravel—over which runs at ordinary times about 8 feet of water, seldom exceeding 12 feet in depth at any time—ultimate stability did not appear so difficult to be obtained as to warrant the adoption of the objectionable mode proposed, of having the under-water work of the piers formed of rough-stone concrete in iron casings,—particularly objectionable in this case, as the bed of the river proved to be much more irregular than was expected. This originated an expedient which, according to Mr. Stephenson's Report, November 1855, led to the adoption of an ingenious arrangement for

Coffer-dams, devised by Mr. Hodges, the superintendent on behalf of the contractors, in conjunction with Mr. Ross, the resident engineer for the Grand Trunk Railway Company, and which, Mr. Stephenson having approved, was consequently acted upon. These contrivances, which Mr. Stephenson calls "floating coffer-dams," were *loaded*, thus at once getting rid of the uncertainty which would result from depending entirely upon piling with a partially rocky bottom.* It being impossible under such circumstances to place full-bottomed caissons,—or to adopt Telford's old-fashioned, however excellent, plan on rock and in still water for a pier or two, of creating an island and then scooping it out for the foundation. These coffer-dams were composed of an outer and inner wall of crib-work of framed timber filled in with stone; each wall was lined with sheet-piling, 8 inches thick, and the space between the two walls filled in with clay puddle, the whole surface of the top being planked over, and also the up-stream surface sloped and planked over as a protection against the ice. The enormous strength and weight of these coffer-dams to resist the lifting-power and momentum of the flood and the floe-ice may be judged, when a single coffer-dam contained, of stone and timber 280,000 cubic feet, and of clay puddle 38,700 feet! The coffer-dams for the abutments were precisely similar in construction to those for the piers, and, owing to their less depth, contained about the same quantity of material.

The piers are of solid masonry, and the contents of each ordinary pier on an average is—

	Cubic feet.
In foundations	19,360
In cut water	35,640
Average shaft	10,098
	65,098

Each of the two centre piers contains, in

	Cubic feet.
Foundations	43,200
Cut water	73,320
Shaft	25,875
	142,395

Each abutment contains 510,962 cubic feet of mason's-work.

The total quantity of mason's-work in twenty-four piers, two abutments, and four small pedestals at the extreme end of the approaches, amounts to 2,797,615 cubic feet. The approaches contain, of earth and gravel, 160,000 cubic yards; stone-facing, 40,000 cubic yards.

The *Abutments* are not solid mason's-work, but cellular, of an exceedingly strong construction. To give additional weight and power to resist by the very inertia the momentum of the floe-ice and its pressure, with the combined weight of the flood and ice, the up-stream cells are arched over and filled in with a species of concrete.

The *Approaches* are very large embankments of earth and gravel faced with stone masonry, in length together 2060 feet, or more than one third of a mile. It will be seen by the section (Plate 21) that the down-stream side has laterally a slope of 1 to 1, or 45 degrees, while that which meets the stream and the floe-ice has in the lower part an inclination so flat as 3 feet retreat to one of elevation. At about half-way up, that slope is increased to 2 feet back to 1 of height, which probably with a view to economy of workmanship, although a considerable increase of material, has been subsequently deemed suitable; and it coincides to a certain extent with Mr. Stephenson's original intention (see his Report, Nov. 1855) to finish with the lighter and much more elegant, if not more efficient outline, which a radius of 60 feet would have described; the three to one being tangential in that case, at about half the height of the embankment.

It will be thus seen that not only has every precaution been taken to avert the action of the flood and ice against the piers and abutments, but even in the up-stream facing of the embankments, which would appear to be almost a superfluity were it not for the fact that previously to the construction of a very expensive wall, about 1840, at Montreal, to counteract it, the ice was forced up the sloping bank of the river, and was known to pile up in a most dangerous manner as high as the windows of

* This agrees with Mr. Brunel's Report, paragraph 28,—30th November, 1858.

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the second-floor of houses situated even 70 yards from the river bank,—accidents frequently occurring.

What we have now written and our previous notice at page 157, with the late Mr. Stephenson's earlier Report, which will be found in vol. xvii. (1854), p. 211, and an inspection of the details given in our Plates 14, 16, 17, 18, 19, 21 and 22, leave us little further to communicate but a summary of the dimensions of the vast tubes that complete this cyclopean structure, which, if it has a fault apart from the ordinary plainness of outline common to all tubular bridges, it is that of excess; but the very opponents of the great man whose genius placed it where it is, admit that no risk whatever in such a case should be incurred; which is a complete answer to those who by an imaginary and small economy might have risked thousands; and it will be remembered that the work has been actually executed under the estimate.

Plate 21 contains a section of embankment, plan of coffer-dam, longitudinal section of ditto with pier standing therein (smaller scale), end view of ordinary pier, and of centre pier. Plate 22 contains (part) longitudinal section, a transverse section of south abutment, and a plan of same taken 32 ft. 6 in. below the underside of tube.

The centre tube is 330 feet between the supports, and weighs as follows:—

	Between supports. Tons	cwt.	qr.	lb.	On the bearings. Tons	cwt.	qr.	lb.
Bottom of tube ...	194	10	0	21	6	1	1	0
Top ,, ...	192	12	1	21	7	5	2	0
Sides ,, ...	177	18	3	21	39	16	0	0
Top & bottom framing (keelsons) ...	57	16	0	21	10	10	0	21
	622	17	3	0	63	12	3	21
Total weight of centre tube ...					686	10	2	21
The expansion rollers and frames ...					13	0	0	0

The tubes next each abutment are 242 feet between the supports, and weigh each as follows:—

	Between supports. Tons	cwt.	qr.	lb.	On the bearings. Tons	cwt.	qr.	lb.
Bottom of tube ...	70	1	0	21	2	19	1	14
Top ,, ...	75	6	3	7	2	8	3	0
Sides ,, ...	84	15	3	0	20	15	2	0
Top and bottom framing ...	21	18	1	0	5	1	3	21
	251	17	0	0	31	5	2	7
Total weight of tube					283	2	2	7
The expansion rollers and frames ...					8	0	0	0

The remainder of the tubes are somewhat heavier than those next the abutments, on account of their increased depth as they approach the central opening. The covering cap on each pier weighs 9 tons. The total weight of ironwork in the bridge is as nearly as possible 8000 tons.

THE SOCIETY FOR THE ENCOURAGEMENT OF THE FINE ARTS.

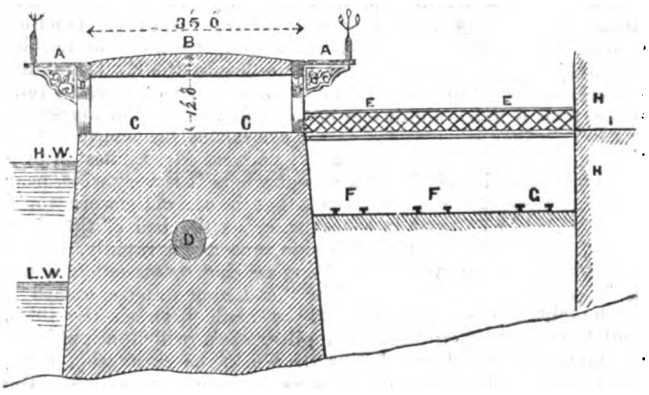
On the occasion of the last general meeting and *conversazione* for the season, held at the French Gallery, Pall Mall, on the 19th of July, the report of the adjudicators on the prizes to be awarded in conformity with a previous resolution of the Society, and of which mention was made some months ago in this journal, was read, when the prize for architectural design (the subject to be selected from either the Royal Academy or the Architectural Exhibition of the current year) was adjudged to Mr. S. J. Nicholl, for his church of SS. Peter and Paul at Cork (No. 64 in the latter gallery), "as being one which from its great merit in many respects is fairly entitled to receive that encouragement which it is the object of this Society to give." Some drawbacks to the design are, however, adverted to, though not deemed sufficiently important to outweigh the general impression. The committee, on entering upon their labours, arranged the following queries to be applied as a test to the exhibited designs for buildings:—1. Does it express its purpose? 2. Is it suitable? 3. Is it consistent in cost? 4. Is the application of materials suitable? 5. Is the style or character correct? 6. Is it original in architectural and artistic composition? 7. Is it harmonious in general outline? 8. Do the various parts form a united whole? As there were several meritorious drawings answering to many of these requirements, hence there was some difficulty in coming to a decision, two other drawings having very nearly an equal claim.

Arrangements are being made in connection with this Society for the delivery of lectures on the History, Principles, and Practice of the various branches of the Fine Arts, on the Thursday evenings in October, November, December, and January; a programme of which will be issued shortly. We trust that the vigorous endeavours of the management will be cordially seconded and supported, and by those especially to whose instruction and pleasure it is their aim more directly to minister.

THAMES EMBANKMENT.

Among the schemes for the Thames embankment proposed to the committee now sitting, is one by Mr. James Edmeston, an outline of which we subjoin.

The road would run from Westminster-bridge to London-bridge upon a river wall as far as Southwark-bridge, and thence to London-bridge upon iron piles, so as to allow craft to pass under to the wharves: from Westminster to Southwark it would be constructed so as to allow access to landing-places beneath, for the use of the owners of river-side property.



Transverse Section of Embankment.

A. Path.
B. Roadway.
C. Landing stage.
D. Intercepting sewer.
E. Platform.
F. Railway for passengers.
G. Line for the use of warehouses.
H. Front of warehouses.
I. Warehouse floor.

The road would pass under all the bridges, including Blackfriars, in which bridge an alteration in the first arch might be effected without stopping the traffic. The river wall would be recessed between Blackfriars-bridge and Southwark-bridge, to allow barges to lie near to the present frontages. The landing-places would be 4 feet above Trinity high-water mark, and the roadway over these recesses would be carried on iron-girders, leaving large open spaces for landing purposes. The railway would run from Westminster-bridge to Queenhithe inside the river wall, just low enough to pass beneath the landing stages or platforms, and thence would be continued in a tunnel to the Fenchurch-street station, and might be extended in a tunnel from Westminster to the New Pimlico station, communicating with the Metropolitan and Hungerford-market stations, and thus connecting all the railways north and south of the river. The entire constructions proposed, except where the river is very wide, would run as close to the side as possible, in order that owners of wharf frontage might receive the least possible injury, and also that the work might be done tide-work, and at as little cost as possible. But little water would be abstracted from the river. Opposite the Temple-gardens, and where desirable, an open arcade would be formed, which would in no way obstruct the view. The railway behind the river wall would be at a level of about 8 feet above low-water. The intercepting sewer, which is proposed by the Metropolitan Board to pass through the Strand and Fleet-street, would pass beneath the railway or in the river wall, as found most convenient.

The estimated cost of the entire construction, except the railway, is £450,000, and some capitalists have had the matter under their consideration, with a view to undertake the whole, including arrangement with the wharfingers, if the public bodies interested would pay a sufficient sum, the road being dedicated to the public use.

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Mr. Edmeston in the course of his examination was referred to Mr. Addington Bird's plan, which has an embankment and a railway behind it, but which in all other respects and in its scope and intention is entirely different to Mr. Edmeston's proposal, which he stated purposely avoids docks and tidal basins, as being no substitute for the river itself. He studies to preserve the river for the use of the wharfingers as nearly as possible as they now have it, giving to each frontage an equivalent private landing-place, for the use and occupation of the owner. The railway is so placed as to pass close under the warehouses, with a third line solely for waggons loading and unloading beneath the cranes. The sole inconvenience to the wharfingers would be, that they must "crane" goods twice, once at the landing-stage or quay, and from thence to the several floors where the goods would be placed; while they would receive the benefit well understood by those in the trade, of having nearly at all times sufficient water at the quay-side to float a barge, so that the delays between the tides, which occasion losses and risks of many kinds and much waste of time, would be avoided: this alone is considered by some wharfingers as a great counterbalance to any inconvenience they could suffer. In Mr. Bird's plan aqueducts are required to give access to the basins, and which he considers might be used for 1½ hour before and after high-water; and as these aqueducts pass over the railway, it is necessary of course to sink the railway a corresponding depth; besides which, in order to obtain the tidal docks, the embankment and railway come far out into the river, and the railway alongside the river in many places passes through a tunnel, so that it is not applied in the way Mr. Edmeston suggests.

All the other schemes before the committee propose to reduce the width of the river considerably; whereas Mr. Edmeston proposes to reduce it only 70 feet, except where it is very wide, near Hungerford-bridge, and he contends that the cost of the work would be very greatly reduced in consequence, as the bed of the river beyond about 100 feet from the side runs down rapidly, and in the deep water the difficulties of engineering construction would be greatly increased; but within the distance above named it is thought the excavation could be made between the tides, scaffolding being erected upon piles, upon which a pumping engine would travel and follow the work, the excavation being filled in with lias lime concrete as the work proceeded. The river wall once erected up to high-water mark, would itself form a dam, which would render the construction of the foundation for the railway easy. The scheme aims rather at being one which would be commercially feasible, than as being a great monument of engineering skill.

The Atlantic Cable.—After numerous fruitless efforts to recover the *débris* of the Atlantic cable, the attempt has been finally abandoned. Mr. Varley, the electrician to the company, in his report just made, writes:—"After repeated attempts to raise the cable by grapnelling, in order to test its electrical condition, and with a view to land it at New Perlican, as instructed by the board, we regret having to report that, although we have on many occasions been able to raise bight, and so get on board at different times pieces of the cable, in all amounting to about seven miles, we have invariably found it broken again a few miles off." Mr. Varley proceeds with a detailed account of the different voyages that have been made in the hope of recovering the cable. Writing afterwards of the bottom near Newfoundland, he says:—"Although mud is shown on the charts, there are unquestionably rocks also, as was too plainly indicated by the state of the cable, rock-weed and sea animalcules adhering to and surrounding it in many places, showing that it had been suspended clear of the bottom. The cable was invariably hauled in by hand to avoid unnecessary strain. The recovered cable varied in condition very much, and what is most important is, that even those portions which came out of the black mud were so perished in numerous patches that the outer covering parted on board during the process of hauling in, and but for the dexterity and courage of the men in seizing hold of it beyond the break, where the iron wires stuck out like bunches of highly-sharpened needle points, we should not have known so much of its condition. Those portions of the recovered cable that were wrapped with tarred yarn were sound, the tar and hemp having preserved the iron wires bright and free from rust. This will be further reported on when the pieces of recovered cable have been more closely examined. It is with deep regret that we have to inform you that it has been necessary to abandon the cable."

Burford's Panorama, Leicester-square.—We had recently occasion to notice the production at this exhibition of the principal inland view (if any can be so termed) of Venice, taken in the great square of St. Mark's. It is now our gratification to mention that a fitting pendant to this panorama has been added in the larger apartment, and that its subject is Rome, viewed from the Capitol. To the lovers of architecture it would be difficult to select two works better calculated to display the characteristic varieties for which each is so renowned, or to enable the spectator to analyse and compare the several parts of each. Rome, indeed, presents a comparatively desolate scene, stripped of the majestic ruins which meet the eye at every turn, and which are here rendered with sadly truthful accuracy. Immediately below the visitor is seen the Forum, with its three stately columns—the questionable remains of the temple of Jupiter Stator; beyond, in the middle distance, is the arch of Titus; while still farther, in nearly the same direction, the overpowering Coliseum arrests the attention to the total exclusion of the minor, though highly interesting, groups around. The muddy Tiber is, of course, another principal feature in the landscape, as it threads its narrow and sluggish way towards the castle of St. Angelo, and the bridge; in which quarter is also to be detected the dome of St. Peter's. Numerous other churches, for the most part marked by their domes and cupolas, diversify the scene, and are deserving of more or less examination, for it is satisfactory to find that in every place a scrupulous fidelity to the originals stamps a value to the student far higher than mere pictorial effect could insure: indeed it is the great charm always to be found in Mr. Burford's panoramas, that besides their artistic merits, their detail will bear the closest scrutiny.

Milton Abbott, Devonshire.—The church at this place (near Tavistock) was re-opened on the 5th ult., having undergone a complete restoration and great improvement. The whole structure, from the foundation of the walls to the pinnacles of the tower, has been restored. Five new windows, in granite, have been fixed, while the others have been almost entirely renovated. The gallery, which obscured the tower window and belfry, has been swept away. The pulpit, reading-desk, and lectern are of carved oak. The chancel is paved with Minton's tiles, the rest of the church with slate of picked quality.

New Church, Northfield.—The foundation stone of a new church at Selly Oak, near this place, was laid on the 12th ultimo. The plan is cruciform, the total length of the nave being 70 ft. 6 in., and that of the chancel 32 ft., the widths being respectively 21 ft. 6 in. and 20 ft. There is an aisle on each side of the nave 12 ft. 6 in. wide, also a vestry and organ chamber on the north side of the chancel, where accommodation is afforded, too, for children. The north and south transepts are each 20 ft. 3 in. wide, and 21 ft. long. The tower and spire at the west end of north aisle rises to a height of 145 ft. 6 in. The sittings are for 617 persons, including 182 children. The style is Early Pointed, and it will be carried out partly in brick and partly in stone, the facing being of Bromsgrove stone with Bath dressings. Internally the columns are of Bath stone, the arches of Bath and Weoley Castle stone, which latter material is also introduced in bands in the walls. Marble shafts are employed under the chancel arch, thus diversifying as well as enriching the effect. The roofs are open, and covered with pattern tiles. The cost of the whole is estimated at about £4000; Mr. Edward Holmes, of Birmingham, being the architect, and Mr. S. Briggs the builder.

The Victoria Bridge, Montreal.—It will be gratifying to the engineering profession to learn that Mr. Hodges, the Resident Engineer of the contractors to the Victoria Bridge, Montreal, has devoted himself to produce perhaps the finest engineering work that has ever yet been issued. The subject is the Victoria Bridge. It is very elaborately illustrated. Mr. Hodges has been assisted by Mr. Weale, the publisher, in preparing the work, which has been done in a very superior manner. A few copies have been specially sent to Montreal for presentation on the occasion of the opening of the bridge by the Prince of Wales, which is to take place on the 25th instant.

Plans are invited for the Mechanics' Institution, Literary Society, and Leeds School of Art, to be erected in Cookridge-street, Leeds. Plan of site and instructions on application. The total cost not to exceed £13,000. The directors do not bind themselves to adopt any plan, nor to employ the architect whose design may be selected; if employed he will receive usual commission; if not will be paid £100, and the design will be the property of the committee. Preference will be given to those plans where readiness of access to the rooms and general convenience have been specially studied.

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THE STONE AT THE NEW HOUSES OF PARLIAMENT.

WHO is there that is not acquainted with the geological commission, authorised in due form some twenty years since, to accompany the chosen architect for the New Palace of Westminster in search of the best and most durable material of which it could be built? and who is there that now does not know the comparative failure of the scheme? Quarry after quarry was explored, until at length the difficulty appeared to be solved: the works were commenced, but soon it was deemed advisable to resort to other sources; various specimens were tried, none altogether satisfactory, yet the building proceeded; but ere it was half completed it was hinted that portions betrayed symptoms of decay; a fact which soon became apparent to the most unsophisticated observer.

Why or how this should take place, either here or in the adjoining chapel of Henry VII.—refaced during the present century, but now becoming as picturesquely shattered and antiquated as the venerable Abbey itself to which it is attached—it is not our business now to investigate; but, inasmuch as certain processes have been employed, with the sanction and under the superintendence of skilful chemists, with a view of arresting, if possible, this work of destruction, and preserving the remaining portions from a like disaster, and as some of the results have recently been brought forward in official evidence, our present object is, as concisely as possible, to give the particulars. The processes which form the subject of examination are respectively those of Mr. Ransome, M. Szerelmey, and Mr. Daines, whose names are already familiar in connection with this subject. It will be unnecessary to allude to the former of those processes, particulars of it having been given in this Journal on former occasions.

In a letter from the Board of Works to Prof. Faraday, dated July 5, 1859, the First Commissioner desires to be informed "whether Ransome's process for the preservation of stone is inferior to that of M. Szerelmey." (On a previous inspection it appears that the processes were deemed to be very nearly balanced in point of merit.) In reply the Professor observes, that he does "not wish to give an opinion, as only between the processes of two persons, Mr. Ransome and M. Szerelmey, both of which are founded upon the process of M. Fuchs, and the use of substances alike in their nature and principle with the waterglass and silicates;" and he adds, "If I were responsible in the present state of the evidence for the selection of one process only for application to the Houses of Parliament, I should select that of M. Szerelmey; but that if I could set apart a fair portion of the building (fair I mean as to exposure and future comparison) for the application of the silicate process (which might be Ransome's) I would do it; and according to the weight of the evidence before my own mind at present, I would try to make this proportion about a third or fourth part of the whole."

In March of the present year, a letter from the late Sir C. Barry, one of the very last he could have penned in connection with his great undertaking, and addressed to the present First Commissioner, contains the following:—"I entirely acquiesce in the favourable opinion given of M. Szerelmey's stone preservative composition by Dr. Faraday and Sir Roderick Murchison. I consider it to be far superior to any composition yet invented, and have no doubt that it will prove to be thoroughly efficient for its purpose." And the same writer adds in a subsequent letter a recommendation that, prior to the application of M. Szerelmey's process, the face of the stone-work should be freed as much as possible from the filth that at present attaches to it, and that the composition, which is colourless, should not have any colouring matter mixed with it.

Mr. Daines' patented process is for "vulcanising and protecting stone-work," and it has been tested during the last six years over from 1500 to 2000 yards at the New Westminster Palace. On the 22nd of last June several professional gentlemen examined the specimens of stone-work to which Mr. Daines had applied his process, and have furnished a report thereon, from which we shall extract the most prominent remarks. The names of the gentlemen just referred to are—Messrs. Sydney Smirke, G. G. Scott, A. Ashpitel, and Edmund Woodthorpe, architects; James Rutledge, Esq., M.D., and Mr. Edward Mackmurdo, of the firm of Davy, Mackmurdo and Co., chemists.

The patented solution had been applied in the year 1854, shortly after the execution of the masonry, and when it was quite clean: the stone is now reported to be in good condition, and without any indications of decay. An adjoining bay having the same aspect, (on the upper floor, west front) and built at the same time, but which had not been prepared, was found to be in part decaying, although generally not in bad condition.

In the court-yards called the Commons' Inner Court and the Peers' Inner Court, the parapets, down to the top of cornice, had been more or less prepared by Daines' process in 1854 and 1856, when some portions of the masonry had already begun to decay. No further decay appears to have taken place. In the latter court the ashlar surfaces which had began to suffer most deplorably from decay, but where the process had been applied to the corroded surfaces, they were now discovered to be quite hard; a fact upon which the examiners comment as being strongly marked, and "the most satisfactory of any we observed,"—the prepared and unprepared parts being brought into close juxtaposition, and presenting very different appearances; the colour of the prepared parts being brighter, and the disintegration completely stopped.

In making the examination of the above-mentioned experiments the chisel was used, also some of the fragments of stone were subjected to heat, and except in two or three doubtful stones the surface proved to have been hardened to a remarkable degree by the application. The effect of the process seems to extend generally to the depth of a quarter of an inch. The parts that had been operated upon gave out a strong smell of oil when heat was applied. Sulphur also, it was evident, had entered into the substance of the stone.

The result of the examination is stated as follows:—"We are satisfied that Mr. Daines' process has generally prevented decay for six years; how much longer it may continue to act as a preservative we have no means of knowing, nor would we venture to surmise. We are further of opinion, that when the masonry is clean on the face at the time when the process is applied, and when due care is taken in carrying out the process, no very sensible change of colour takes place."

Various specimens of Anston, Bath, Caen, and Tunbridge Wells sandstone, which had been experimented upon by Mr. Daines, were also examined on the 27th of June, and the extent of the absorption of the solution in each was carefully noted. Thus, a piece of Anston stone, which Mr. Daines had prepared in 1856, by laying its surface in the solution one-sixteenth of an inch deep for twenty-four hours, had absorbed the solution to the depth of seven-sixteenths of an inch, to which depth the stone appeared to have become to a great degree repellant of water. An experiment on Parian cement, which had received five coats, showed the prepared side to be much harder and more repellant of water, the solution to have been absorbed to the depth of about one-eighth of an inch.

Mr. Dugald Campbell, the analytical chemist, detected the presence of sulphur in a piece of stone forwarded to him for examination, though the percentage of sulphur held in solution by the oil itself was small. Mr. Campbell adds, that he also coated the surface of a moderately porous stone with the solution, and that, on examining the saturated portion, it was apparent that the sulphur had penetrated into the stone along with the oil, and was not all deposited from it on the surface of the stone.

THE BRITISH ARCHÆOLOGICAL ASSOCIATION.

EXACTLY five years ago the members of the Archæological Institute of Great Britain and Ireland held their annual gathering at Shrewsbury. During the week that they remained their scientific researches and investigations were directed not only to the more interesting portions of the town, such as the Castle, Free Schools, the various Churches, Museum, &c., but were extended to Hawkstone, Ludlow, Wenlock, Haughmond Abbey, and other celebrated spots. And now another society has spent several days in exploring these and other objects, for purposes analogous to those of the Institute. On the 6th and following days of last month the congress whose proceedings we are about to chronicle held their seventeenth anniversary meeting, including in their visits Shrewsbury as the starting point, then Buildwas Abbey, Wenlock Priory, Shiffnal, Tong, Lilleshall, Ludlow, Stokesay, Battlefield, Haughmond, Wroxeter, &c.

At Shrewsbury the town hall was placed at the disposal of the Association; when the president, Mr. Beriah Botfield, M.P., addressed the meeting at considerable length in a dissertation of much interest, and evincing considerable research, referring

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of course chiefly to local historical events and antiquities. Alluding to Shrewsbury, he remarked that in the tenth century it was the scene of direful conflicts between the Danes and Saxons, who in 941 agreed to make the Watling-street their boundary. But the former were ultimately expelled, and Sciropesberie, in which we at once recognise the present Shrewsbury, was esteemed by the great Alfred one of his chief cities. It formed a place of refuge for the Britons after the destruction of Wroxeter, from the natural defence afforded by its situation on the banks of the Severn. The place increased so much in importance that Athelstane established a mint there, which was continued by his successor. The piety of the Saxons founded the churches of St. Ceadda, or Chad, in 780, St. Julian's at an early period, St. Alkmund's in 900, and St. Mary's in 980; of these, the three former having becoming dilapidated, have been taken down and replaced by debased structures of the last century. St. Mary's alone remains, an interesting example of Gothic architecture, restored in the improved taste of the present day. At the conclusion of this preliminary meeting, the company at once adjourned to the venerable abbey, whose history and antiquities were described by Mr. C. E. Davis. He remarked that it was but a mere fragment of the old building. A central tower had sprung from the tops of the present pillars on either side the chancel window, and that the original chancel had extended beyond this, and was probably terminated by an apse, The western tower was of much more recent date, and was no doubt intended to be carried much higher, but, for some reasons which could not now be satisfactorily ascertained, it was stopped short, and finished in a totally different style. The lower part of the window—a very fine one—is now unfortunately concealed by an unsightly screen. The nave was originally of one style, but now consisted of three Norman bays on each side, with two others at the west end of a subsequent date. The chapter-house no longer exists, but the door from the south of the church to the cloister is still visible. He doubted if there had ever been a lady-chapel. Proceeding down the south aisle, Mr. Planché, F.S.A., offered some erudite observations on some of the monuments. The first against the south wall is by common report assigned to the memory of Roger de Montgomery, first Earl of Shrewsbury, and upon the spot where he was buried; but the speaker considered that its appearance did not bespeak so early a date, and suggested that it more probably was only of about the time of King John. In connection with a very ancient stone monument or sepulchral slab at the lower end of the south aisle, Mr. Pettigrew, F.S.A., treasurer, observed that it was an example of a very rare kind, if not unique, being a slab placed over the tomb of a clerk in minor orders, and its date might be assigned to the thirteenth century. The effigy was habited in an alb, and four symbols appeared, which he took to indicate that order; there was first a bell, next what seemed to be a chalice, but which had been conjectured upon good authority to be a holy water vat; third, a book; and fourthly, a lighted taper. The tombs of ecclesiastics below the order of the priesthood are exceedingly rare, and an excellent antiquary stated that he only knew of three that had been erected to deacons, The next tomb which came under examination was that of a cross-legged knight in armour, supposed to be an effigy of Walter de Dunstanville, who died in 1196; Mr. Planché however surmised that its real date might be about 1230. Another recumbent figure in the north porch is described in the guide books as being in plate armour, which is a great error, it being a fine old figure of the time of Edward III., in civil attire of state. It has the mantle of state similar to those in all civil effigies of that period, and was removed from St. Alkmund's church when the old structure fell down. Another adjoining, also from St. Alkmund, might be attributed to about the same age, or possibly rather older, and commemorated apparently some merchant or official. Retracing their steps to the outside, Mr. Davis resumed his observations, and drew attention to the curious ancient stone pulpit in the garden, supposed to have formed part of the refectory; also pointing out how the walls had extended across the present road, parallel with the western entrance wall, as far as where the old pulpit stands.

St. Mary's Church, before alluded to, was next inspected, and described by Mr. Edward Roberts. It consists of a nave and chancel (24 feet wide and about 136 feet, or including the tower, 160 feet long), north and south aisles, transepts, with large chapels, north and south porches, with a solar or library over one. The lower part of the tower is Norman, but it has been considerably altered internally. The earliest portions of the edifice he thought belonged to about the end of the eleventh century; other parts were of later date, down to the Lancasters and Tudors. The lancet windows in the chancel are very good specimens of the Early English style. In the arch between the south chapel and the nave is a table tomb, with an effigy of a cross-legged knight, of fourteenth century work, very similar to the one in the abbey. The tomb is beautifully arcaded in the canopy style of that period. There is an unusual quantity of fine stained glass also, brought from several places, but it has been much and well repaired.

Mr. G. Gordon Hill's paper on "Buildwas Abbey" was a very admirable contribution, and, being illustrated by a ground plan and other drawings, was rendered very intelligible throughout. He said, "This building is a fine example of the smaller class of Cistercian abbey churches. Every part of its arrangements is preserved or distinctly traceable. The width of the aisle on each side of the nave is marked, though the inclosing walls are gone. The convent brothers and lay dependents of the monastery were placed during divine service at the west end of the church. Their entrance from the great cloister, I think, must have been close to the west end of the north aisle. This position is not quite usual for a door, nor is it usual for a church to be without an entrance at the west end of the nave, which clearly was the case here. My reason for believing the door to have been close to the end of the aisle is, that the western of the nave arches is some inches wider than the others. The massive proportions of these arcades, and the scolloped capitals of their columns, indicate the prevalence of the Norman style of architecture; while the pointed arches show an approach towards the style which early in the thirteenth century superseded the Norman, the union forming the transition style which began about 1150. The clerestory remains entire on both sides, and has round-arched windows throughout. Advancing to the east we find between the columns indications of a stone screen, which shuts off the aisles, leaving them as mere passages; and at the end of the fifth arch from the west we ascertain that the choir, or portion devoted to the monks themselves, commenced. The bases of the columns here and eastward are raised, so that the choir must have been entered by an ascent of four steps, in which proportion also the marks on the columns show that the side screens were raised, forming the back of the stalls. The stalls extended up to the first great transverse arch, and would seat about thirty-four monks. The number originally on the foundation is not known; at the time of the suppression it is reported to have been only twelve. I may here remark, that from the number recorded to have inhabited other monasteries, we may conclude the whole of the lay inmates to have amounted to about five persons for each monk."

(To be concluded in our next.)

CONTINENTAL PUBLICATIONS.

Among the works recently published in Paris, there are none that better deserve to be widely known in this country than those of M. Viollet-le-Duc. His Dictionary of French Architecture, relating exclusively to mediæval art, is a standard work, and we hope to find an opportunity of describing it at length. Not less valuable to the architect or the archæologist, or less beautifully got up, is his Dictionary of French Furniture, a book perhaps less known among us than the first mentioned. We propose in the present notice to give some account of the 'Discourses' (*Entretiens*) of M. Viollet-le-Duc, a work of which only the first volume is at present out, though the second is said to be in course of publication.

That M. Viollet-le-Duc is a sagacious observer, a profound thinker, an able writer, and a learned and skilful architect, is known by all who are familiar with his dictionaries, but from these works, and the almost exclusive preference given in them to mediæval work, it has been at times supposed that he is a partizan, and a prejudiced one, of mediæval architecture solely. This has unfortunately been the case to a great extent with the writers upon Gothic art both in our own country and on the continent; and it is therefore a peculiarly pleasant task to draw attention to the Discourses, a work of the most comprehensive and large-minded scope, and treating of the bearings of architecture in its relation to the civilisation and social condition of the different nations of Europe, in the ablest and most enlightened manner possible.

These Discourses were originally prepared for delivery as a

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course of lectures on theoretical and practical architecture, and the scope of them is thus explained in the introductory observations: "The first volume will include general observations on art, the developments of architecture among the peoples of antiquity from the Greeks to the Lower Empire, and the history of the applications of ancient art during the middle ages and down to modern times; and it will treat of the various modifications of architecture among western nations, from Charlemagne down to our own day.....The second volume will treat only of the practice of architecture in its various branches, of the ancient modes of construction compared with those of the present day, of the mode of carrying on works, of decorations, and public solemnities and fêtes."

We have no book in the English language that takes this line of investigation, or at least none that pursue it in the philosophical manner of M. Viollet-le-Duc. The writings of Mr. Ruskin are somewhat similar in the analysis they in parts present of objects of art or styles of architecture, but although the French writer does not equal in beauty the best passages of Mr. Ruskin's eloquent pen, he is the superior in judgment and sagacity, and has especially the advantage, when writing upon architecture, of a profound acquaintance with the practical bearings of the subject, beyond anything to which the English critic can lay claim. We select almost at random, as an illustration of this work, an extract or two, which we translate from the second discourse.

"The spirit of the Romans was quite different from that of the Greeks. The Roman is a politician and an administrator before all else: he has founded modern civilisation. Is he an artist, such as were the Greeks? Most assuredly not! Is he endowed with that instinct which enables certain privileged organisations to give to every conception of the mind a form that shall be a direct emanation of art? No, he proceeds quite otherwise. If we analyse the buildings of the Grecians, as we have just now very succinctly analysed a Greek temple, we invariably meet with the same subtle, delicate genius, knowing how to turn every difficulty to good account, and every obstacle to the advantage of art, even down to the minutest details. The analysis of a Roman monument reveals to us other instincts, other aims. The Roman only looks at the whole, the gratification of a satisfied want, He is no artist; he governs, he administers, he constructs. The form is to him nothing more than a covering with which he clothes his structure, without any over-anxiety as to whether the garment is perfectly in accordance with the body, and all the parts are deduced from one leading principle. He does not stop for these refinements; provided only the covering be ample and substantial, worthy of the thing covered, and an honour to the person who caused it to be made, it is of scant importance to him whether or not it also fulfils those conditions of art which the Greek requires.

"It is useful to trace with precision the boundary line which separates Greek art from Roman art. To know thoroughly the properties peculiar to these two civilisations is the best method of explaining the development of modern arts, and of appreciating what we have taken, and what we have yet to take, from the one and from the other; for if we are Latin in tongue, in political manners, and in actual habits, we are to some little extent Greeks in the nature of our spirit and our genius."

We recently gave, among the notices under this head, some account of the 'Archives des Monuments,' &c., the great work now publishing under the auspices of the French government; and on that occasion some further description of the work as far it has been published was promised.

The publication of the parts proceeds slowly and irregularly, the plates being apparently issued as they are ready, and with no particular regard to the order in which they are to stand ultimately. The descriptive letter-press is continued with each part, and sometimes is explanatory of plates in that part, but more frequently is not so; and therefore until the work is quite finished it cannot be perfectly arranged or judged of. This accidental inconvenience however cannot detract from the actual merits of the book, and the great beauty of its engravings, which are all folio size, and executed in the best possible style.

The plates published contain more churches than other buildings, and examples of the Round-headed and Early Pointed styles of French architecture preponderate over those of its later developments; but this is by no means exclusively the case, and perhaps the most striking drawings are those of the Citadel of Carcassonne and the Castle of Blois. Carcassonne, in its seclusion on the top of a steep crag, has preserved its mediæval character more undisturbed than any other city of France. Its walls and forts are a perfect study: its streets are as tortuous, as picturesque, and as ill kept as they can have been in the middle ages; and its singular but beautiful cathedral is a fitting centre for the mass of antiquity which the old walls encircle. Most of all the fortifications are regarded as the best specimens extant, and they have been illustrated at great length in this volume, together with views and plans of the entire city, the cathedral, and the various approaches. Nothing except a visit to the place itself could give a more complete idea of its curious character. The renderings of the Chateau of Blois, very different in the manner of execution from those of Carcassonne, are so done as to suit perfectly a monument whose principal charm is not so much antiquarian as picturesque. The illustrations are fac-similes of pen-drawings in brown ink, but done in so masterly a style as to recall more the accuracy and brilliant light and shade of a photograph than any sort of handwork whatever. The well known staircase of this chateau, which has served for a model to many since, though not one of them equals it, is illustrated in several plates.

Next in beauty to the set of drawings illustrating Blois we may mention the exterior views of the Church of Vétheuil. They are only elevations, but are so marvellously executed, and so perfectly shaded, that the effect of them is more charming and more *solid* than that of most perspectives. Nearly all the exteriors are given in elevation, and the best of them, like those we have just mentioned, are models of the best treatment of such subjects.

Several other churches are more or less fully illustrated, and all of them have some recommendations to notice, either in their plan or features, or else in their general beauty or peculiarity, or as types of a class. Among the secular buildings may be noticed the Synodical Hall of Sens, a work, small though it be, yet well deserving the attention of those who are studying how to give appropriate treatment to secular buildings erected in the geometrical style of Gothic; the character of the exterior perfectly expresses the intention of the building, and though quite in keeping with the church architecture of the same period, is yet thoroughly and unmistakeably distinct from it.

Lastly, true to the intention they announced themselves to entertain, of illustrating the monuments of all ages in France, the directors of this work have devoted some plates to the Roman remains in the south, the Amphitheatre of Arles, and the remarkable Roman water-sluice near Nismes. Italy scarcely presents any remains of public works more perfectly preserved, or evincing more ability in their original design, than those of the south-eastern provinces of France, and they have thus very appropriately been included among the "monuments."

LONDON IMPROVEMENTS.

Persons remembering what London was forty years ago, and observing the changes that have taken place, can come to no other conclusion than that the whole period has been one of transition; for narrow ways we have wider ones, for low, inconvenient, and badly-ventilated dwellings of no architectural pretension, the walls pierced with pigeon-holes for windows, we have now in almost every kind of style lofty structures evincing considerable improvement. The houses are generally better arranged for every purpose,—the rooms loftier, the windows larger; whilst the security of fire-proof rooms, the improvements in warming, lighting, and ventilating, and the great advantages derivable from water-closets, improved sewerage, and the mechanical arrangements for closing almost instantaneously at night the larger mercantile establishments, show that our architects, builders, and machinists have not been idle in producing those important changes which a progressive age required, and for which the public generally have much to be thankful. Yet with these advantages over by-gone days there are many things that might have been better ordered in high places. This is evident in many of the altered parts of the metropolis, and conspicuous in New Oxford-street, Cranbourne-street, and Farringdon-street. In many parts of the first great thoroughfare more ground was required, and for want of it many of the houses are mere fronts, and are scarcely of any use to an occupant, the ground plots being of such shape that no person save a government commissioner could have thought them fit for covering. Unfortunately, upon these irregular sites buildings have been erected, and the consequence is that they are found so unsuited to business purposes from contracted space, that no tenant can remain in them, and thus numbers of such dwellings in these new and faulty ways are studded with notices "to be let," conveying no other suggestion to inquirers than "let these useless abortions alone." The same evil exists in Cranbourne-street, and has been productive of the same results, rendering a great place of business a spot where not one-third the amount is now transacted,

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although the alteration has taken place many years. This is wholly attributable to the cause we have mentioned, and the extravagant ground rentals. Another reason may be that it is a main line of thoroughfare with no proper and respectable outlet for carriage traffic towards the east, save Drury-lane and Queen-street, consequently this lengthy mid-way is as it were sealed up at one end; yet for an almost inconsiderable expenditure a fine outlet either into Holborn or the Strand might be obtained by widening Great Turnstile, and carrying a direct roadway along Serle-street, across Carey-street, and through that abode of wretchedness contiguous to Ship-yard, into the Strand. This change would also provide a wide omnibus and carriage route from Holborn *vid* Lincoln's-inn-fields, Great Queen-street, Long-acre, Leicester-square, into Piccadilly, which is scarcely more than a pedestrian route. Another desideratum would be the obtaining a good wide cross thoroughfare from Holborn to the Strand, avoiding the narrow inconvenient end (at Holborn) of Chancery-lane, and which could be carried out with but little interference with the large site in the same locality proposed to be appropriated for the erection of the new law courts.

A great mistake has always been committed by altering the established line of communication, which necessarily breaks up a vast business locality, and takes years to re-establish it, if it ever does. The evil we speak of occasioned by the New Oxford-street route is observable in Broad-street, St. Giles', and in New Farringdon-street. We may ask, what has been obtained by the removal of Fleet-market to its present situation, but extensive failure and bad accommodation? The evil complained of, "the market encroaching on a public thoroughfare," has consequently taken root in another locality (Leather-lane), where it now exists with the same inconveniences in a more confined public way. Had Fleet-market been rebuilt instead, in a style suited to a central position in a great metropolis, and with buildings well and suitably contrived for salesmen and tradesmen, with the roadway sufficiently widened on the sides, which could have been done at about the expense of clearing the space away and erecting the almost useless new market, the whole trade of the immediate neighbourhood would have been preserved. Markets surely might be made an imposing, instead of an unsightly feature in a metropolis, and of the greatest public utility, if they were only placed in open spaces, and provided with suitably wide public approaches; but unfortunately there is scarcely any market in London that is in such a state: even in the best (Covent Garden) the space is lamentably insufficient for its traffic, and it is most incommodious both for sellers and buyers, and in no direction has it fitting approaches. Southampton-street is a hill, Great Russell-street is approached in a direct line by an unuseable narrow way, and James-street is equally bad, whilst the market space is only half large enough for the business to be transacted, consequently a nuisance and blockade takes place in all the surrounding thoroughfares: this surely ought not to be.

The new approach now in course of formation eastward towards the market from the end of Cranbourne-street, by an angular cut from St. Martin's-lane into King-street, will again divert an established business route. And to our minds this indirect new street appears to be in the wrong place, and will no doubt lead either to the destruction or removal of half the trade of a busy locality. It strikes us that the proper and required alteration would have been to widen New-street to the width of King-street; and then form a short new street in a continuous line westward through St. Martin's-court and Bear-street into Leicester-square. The dwellings and business along this line from their declining state, ever since the alteration of Cranbourne-alley, would have rendered a change easy of accomplishment, and at no vast expense. By this means a direct line of thoroughfare into the market from the western road, through Piccadilly, would have been obtained; whilst an opening from Holborn through Great Turnstile, by the removal of about two houses at the end of Great Queen-street, would have provided a sufficiently wide carriage route westward to relieve Holborn of its over-crowded traffic.

As this new thoroughfare progresses to completion we prophecy it will be found as abounding with buildings covering sites of the same inconvenient and limited forms as the great new street to which we have before alluded. This remark is illustrated by the first building erected here,—that for the firm of Messrs. Debenham, Storr, and Sons. The difficulties which the architect, Mr. Arthur Allom, had to surmount, arising from the irregularity of the site, will be understood by a reference to the accompanying plans. The building occupies some 4800 superficial feet, and is Italian in style; its front being 117 feet, the greatest depth 55 feet, and the elevation above the street 60 feet. It comprises five stories. The basement is appropriated to warehousing and arranging the property to be sold, and to vaults for wine: it is 11 ft. 6 in. in height, well lit and ventilated, and is provided with two strong rooms, fitted with Chubb's patent doors, all fire-proof, and a lift for raising heavy goods to the sale-rooms. Upon this story is the Perkins' hot-water apparatus for warming the rooms above. The principal entrance properly occupies a central position, this leads to an elegant hexagonal hall covered with Maw's tiles. On the sides next the entrance are polished wainscot folding-doors; those on the right conduct to the clerks' and private offices, and those on the left to the large auction-room. The entrance hall exhibits much good taste and originality, its ornamentation is most chaste, and the circular opening in its domed ceiling surrounded by balusters with a corniced capping is excellent.

The principal sale-room on the ground-floor is 24 feet in height beneath the lantern, and occupies about 1160 superficial feet. It is ventilated by pierced iron-work in the ceiling, that admits of being closed or opened at will. Further ventilation, if required, is obtainable from the windows in front, and by the series of swinging sashes moving by mechanical contrivances in the sides of the lantern. Solid oak counters are placed across and around the rooms, that on the front side concealing the basement windows. Along the middle of the room runs a range of iron columns, supporting a box girder that carries one of the main walls of the building. In the north corner is placed another prominent feature, the rostrum, which is so constructed as to transmit the auctioneer's voice to every part of the room. Quitting the auction-room, and returning to the hall, as we ascend the principal staircase of Portland-stone, our notice is attracted by a novelty, the dado of ornamental tiles lining half way up the side wall, which produces nearly the effect of a mosaic enrichment. This flight of stairs leads to a hall of similar form to that beneath, having a pendentive ceiling, and angle piers remarkable for neatness of design and classic ornamentation. Passing from the hall, on the right is a second sale-room, with rostrum in Spanish mahogany of effective design. The other portion of this floor is occupied by a waiting-room and the offices of the principals, which communicate with those below by a compact light spiral staircase; these offices, like those of the clerks beneath, are elegantly fitted. The upper floors contain twenty-one lofty rooms, forming handsome suites of apartments, devoted to domestic purposes. The architect has contrived to render most of these rooms of regular shape, a task not easily accomplished considering the site.

The building from the street has two other well proportioned entrances besides that in the centre; one of these, the private entrance, adjoins the Westminster Fire Office, and leads to the private staircase communicating with each floor. The third, the business one, at the northern end of the building, has an inclosed lobby adjoining the lift, and communicating with the basement and principal auction-rooms. The façade is praiseworthy for a simplicity that has contributed materially to its effectiveness, whilst many portions exhibit great boldness and originality. The windows with their dressings are exceedingly good in form, and the splay given to those of the ground and first floor stories is most judicious. The ornamentation throughout the front is novel and elegant, and no more is introduced than is absolutely needful; we are glad to see a natural type has been selected by Mr. Allom for the ornament, rather than the hacknied forms so frequently introduced. Much praise is due to him for the style of the iron-work, which is massive and appropriate.

The whole of the work has been executed in the most excellent and finished manner. Messrs. Mansfield were the contractors for the building; Mr. W. Williams provided the ironwork, Messrs. Ransome the siliceous stone, Mr. Drew the mahogany fittings and Mr. Strode the gas fittings.

References to Plans.

Ground Plan.

A, Principal entrance and hall.
B, Private entrance, hall, and staircase.
C, Goods entrance.
D, Large auction-room.
E, Principal staircase.
F, Air shaft.
G, Private staircase.
H, Clerks' offices. I, Private offices.
J, Spiral staircase to first floor.
K, Lift. L, Rostrum.
M, Counters.

Second Floor Plan.

A, Private staircase. B, Passage.
C, Sitting-rooms.
D, Bed-room. E, Dressing-room.
F, Housekeeper's sitting-room.
G, Housekeeper's bed-room.
H, Linen-room.
I, Kitchen.
J, Back passage.
K, Servants' stairs. L, Pantry.
M, Larder. N, Scullery.
O, Lift. P, Closet.

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BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Thirtieth Annual Meeting, held at Oxford, 1860.

(Continued from page 238.)

Experiments to determine the Effect of Vibratory Action and Long Continued Changes of Load upon Wrought Iron Girders. By Wm. Fairbairn, LL.D., F.R.S.

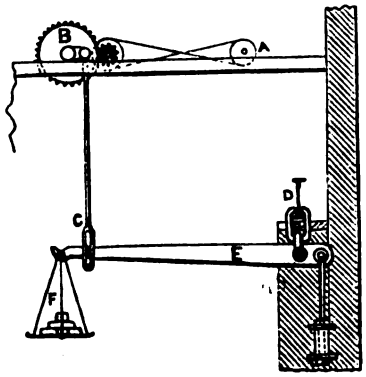
Amongst engineers opinions are still much divided upon the question, whether the continuous changes of load which many wrought-iron constructions undergo has any permanent effect upon their ultimate powers of resistance. That is, whether a beam or other construction subjected to a perpetual change of load would suffer such a change in the structure of the iron or the tenacity of the joints, that it would in time give way with a much less force than its original breaking weight. But few facts are known and few experiments have been made bearing on this question. We know that in some cases wrought-iron subjected to continuous vibration assumes a crystalline structure, and is then deteriorated in its cohesive powers; but we are yet ignorant of the causes of this change, and of the precise conditions under which it occurs.

A few experiments were made by the Commission appointed to inquire into the Application of Iron to Railway Structures to ascertain the effect of changes of load upon homogeneous bars of wrought and cast iron. They found with cast-iron that no bar would stand 4000 impacts bending them through one-half of their ultimate deflection, but that sound bars would sustain at least 4000 impacts bending them through one-third of their ultimate statical deflection. They ascertained also that when the load was placed upon the bars without impact, if the deflection did not exceed one-third of the ultimate deflection, the bar was not weakened, but that if the deflection amounted to one-half the ultimate deflection the bars were broken with not more than 900 changes of load. With wrought-iron bars they found no perceptible effect from 10,000 changes of load when the deflections were produced by a weight equal to half the statical breaking weight.

These experiments are interesting so far as they go, but they are very incomplete as regards wrought-iron. For wrought-iron bars they were not continued long enough; nor do they apply to those larger constructions in which the homogeneous bar is replaced by riveted plates. The influence of change of load on rivetted constructions possesses a special importance, from its bearing on the question of the proper proportion of strength in plate and tubular bridges.

The questions for solution are, Do these constructions gradually become weaker from the continued passage of trains; and is it requisite to make allowance for such a deterioration (independent of atmospheric influence) by increased sectional area of material in their original construction? These questions I have sought to solve by the following experiments.

As the load is brought upon bridges in a gradual manner, the apparatus is designed to imitate as far as possible this condition. A riveted beam is fixed on brickwork supports, 20 feet apart. Beneath this is placed a lever with a shackle grasping the lower web of the beam, and fastened upon a pivot at the extremity, forming a fulcrum to a powerful lever. At the other extremity the lever carries a scale and weights, and is lifted clear of the beam and again lowered upon it by means of a crank and connecting rod attached to one of the arms of a spur-wheel placed at a considerable distance overhead. In this way any required part of the breaking weight can be lifted off and placed upon the beam alternately by the revolution of the spur-wheel. The apparatus is worked night and day by a water-wheel, and the number of changes of load is registered by a counter.



The girder subjected to vibration in these experiments is a plate girder of 20 feet clear span, and of the following dimensions:—

	Square inches.
Area of top: 1 plate, 4 inches × ½ inch	2·00
2 angle irons 2 × 2 × $\frac{5}{16}$	2·30
	4·30
Area of bottom: 1 plate 4 inches × ½ inch	1·00
2 angle irons, 2 × 2 × $\frac{5}{16}$	1·40
	2·40
Web, 1 plate 15¼ × ⅛	1·90
Total sectional area	8·60
Depth	16 inches.
Weight	7 cwt. 3 qrs.
Breaking weight (calculated)	12 tons.

This beam having been loaded with 6643 lb., equivalent to one-fourth of the ultimate breaking weight nearly, the experiment commenced as follows:

Table I.—*Experiment on wrought-iron beam with a changing load, equivalent to about one-fourth of the breaking weight.*

Date.	Number of Changes per Load.	Deflection produced by Load.	Remarks.
1860.			
March 21	0	0·17	
,, 22	10,540	0·18	
,, 23	15,610	0·16	
,, 24	27,840	.....	Strap loose, and failing to lift the weight.
,, 26	46,100	0·16	
,, 27	57,790	0·17	
,, 28	72,440	0·17	
,, 29	85,960	0·17	
,, 30	97,420	0·17	
,, 31	112,810	0·17	
April 2	144,355	0·16	
,, 4	165,710	0·18	
,, 7	202,890	0·17	
,, 10	235,811	0·17	
,, 13	268,328	0·17	
,, 14	281,210	0·17	
,, 17	321,015	0·17	
,, 20	343,880	0·17	Strap broken.
,, 25	390,430	0·17	
,, 27	408,264	0·16	
,, 28	417,940	0·16	
May 1	449,280	0·16	
,, 3	468,600	0·16	
,, 5	489,769	0·16	
,, 7	512,181	0·16	
,, 9	536,355	0·16	
,, 11	560,529	0·16	
,, 14	596,790	0·16	

As the beam had now undergone above half a million changes of load, that is it had been worked continuously for two months, night and day, at the rate of about 8 changes per minute, and as it had undergone no visible alteration, the load was increased from one-fourth of the statical breaking weight, and the experiment proceeded till the number of changes of load reached a million.

Table II.—*Experiment on the same beam with a load equivalent to two-sevenths of the breaking weight, or 7840 lb.*

Date.	Number of Changes of Load.	Deflection in inches.	Remarks.
May 14, 1860.	0	0·22	
,, 15	12,623	0·22	
,, 17	36,417	0·22	In this table the number of changes of load are counted from 0, although the beam had already undergone 596,790 changes, as shown in the preceding table.
,, 19	53,770	0·21	
,, 22	85,820	0·22	
,, 26	128,300	0·22	
,, 29	161,500	0·22	
,, 31	177,000	0·22	
June 4	194,500	0·21	
,, 7	217,300	0·21	
,, 9	236,460	0·21	
,, 12	264,220	0·21	
,, 16	292,600	0·22	

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TABLE II. (continued.)

Load equivalent to two-sevenths of the breaking weight.

Date.	Number of Changes of Load.	Deflection in inches.	Permanent set in inches.
June 21	327,000	0·23	+ 0·01
„ 23	350,000	0·25	+ 0·01
„ 25	375,650	0·23	+ 0·03
„ 26	403,210	0·23	+ 0·03

The number of changes of load now amounted to a million; that is, 596,790 changes with a load equal to one-fifth the breaking weight, 403,210 with a load equal to one-fourth the breaking weight. Neither of these had produced much effect upon the beam, except a slight increase of permanent set in the latter experiment. The weight was now increased to one-third of the breaking weight.

TABLE III.

Load equivalent to two-fifths of the breaking weight.

Load = 10,486 lb. = 4⅔ tons.

Date.	Number of changes of load.	Deflection in inches.	Permanent set in inches.
June 27	0	0·35	0·05
„ 28	5175 ...(broke.)		

With 5000 changes of load nearly, the beam broke across the bottom plate and angle-iron, and part way up through the side plate. The fracture occurred in the middle, through two rivet-holes immediately under the shackle from which the load was suspended.

Since the commencement of the present meeting of the British Association, I have received from Manchester the above statement announcing the breakage of the beam after having sustained 500,000 changes of one-fourth of the breaking weight, and about the same number of two-sevenths of the breaking weight; and that it ultimately broke after sustaining 5175 changes with a load of 10,486 lb., or two-fifths of the load that would break the beam. In the attainment of these results it must be borne in mind that the beam had been submitted to severe tests, upwards of a millions times repeated before fracture ensued, and that the molecular constitution must have suffered considerable injury before it finally gave way.

In a professional point of view these facts are of great importance, and having obtained the permission of the Board of Trade to submit the whole of the experiments to the British Association for the Advancement of Science, I would respectfully ask that the President and Council of Section G would recommend that these experiments be continued.

It appears to me essential that this should be done in order to ascertain a series of facts so intimately connected with the durability of structures on which not only the property of individuals and public companies, but the lives of the community, depend.

During the whole time of the changes to which the beam was subjected, lasting from March 21 to June 26, considerable strains from vibration and of impact were produced by the sudden fall of the lever when liberated by the connecting rod; and these vibrations continued until the succeeding lift, when the connecting rod came in contact with the pin by which the lever was raised to the proper height clear of the beam.

Description of Woodcut.—A is a shaft and pulley driven by a water wheel; B a wheel and pinion giving motion to the connecting rod C, which lifts the end of the lever and load from off the beam shown in section at D, with the shackle and clip *a*. At the lower end of the connecting rod C, is a slot made for the purpose of allowing the load to come fairly upon the beam before the next suspension. E the lever, and F the scale, for regulating the weights. On the top flange of the beam was stretched a gauge to ascertain the deflections during the changes and vibrations produced by the different loads. And an engine counter was attached for registering the number of changes of load.

The Cylindrical Spiral Boiler. By JOHN ELDER.

THE object of the construction of this boiler is to obtain a form with all the useful properties of the simple cylindrical high-pressure boiler on shore, adapted to steam-ships. The following advantages appear to be attained over the ordinary marine boiler, namely:—

1. A form of boiler capable of carrying higher pressure and presenting more heating surface, and of a more effective description, from a given weight of material.

2. A boiler capable of being easier cleaned and repaired in both water and fire spaces.

3. A boiler capable of producing superheated steam to any practical temperature.

4. A less average specific gravity of water whilst working at sea with the usual amount of feed and blow-off, and a more perfect combustion-chamber, and better formation of flue surface.

5. The pressures being altogether internal it is not liable to collapse, a danger lately ably demonstrated by Mr. Fairbairn; and as the diameter of the various cylinders are reduced to the minimum size for permitting the tradesmen to pass through, clean and repair them, the boiler when formed of ordinary thickness possesses enormous strength without stays.

6. The expense of the boiler per square foot of heating surface is about the same as the ordinary boiler, and is capable of carrying five times the pressure.

The general construction of this boiler is as follows:—There are twenty-four round boilers or tubes, of not less than 19 inches diameter each, twenty-two of these forming, when bound together, a cylindrical vertical shell; the twenty-third, a centre boiler concentric to that shell; and the twenty-fourth, a spiral coil-boiler winding spirally round between the centre boiler and those composing the circumference shell. These boilers contain the water, and the spaces between them the fire.

The feed-water passes first into the spiral compartment or No. 24, and from it into the centre compartment or No. 23, and into each in rotation, and blows off at the last compartment or No. 1, thus rendering the water in No. 24 nearly pure sea-water, and gradually from compartment to compartment more dense, till it blows off at No. 1 at the usual density, and thus makes the average specific gravity of the water less than usual.

The twenty-two outside boilers are 24 feet long, 19 inches diameter, and $\frac{5}{16}$-inch thick; the bottom ends are conical for 3 feet, and knee'd outwardly to give a larger diameter of furnace, say 12 feet diameter. There is a furnace-door for every alternate tube, or say eleven furnace-doors, equally divided round the base of the boiler, giving great facility to the firemen for doing their work efficiently. In firing it is proposed to charge all the fresh coal round the circumference of the fire, in order that the hydrogen of the coal may be consumed separately from the carbon; and as the furnace has great altitude the combustion will be completed in vertical flames from the coals, and will thus prevent the carbonic acid gas given out from the combustion of the carbon coming so much in contact with and preventing the combustion of the hydrogen, as is usual in ordinary furnaces.

The centre compartment, or No. 23, is 30 feet long, 34 inches diameter, and $\frac{3}{8}$-inch thick, with 3 feet at the bottom and top conically reduced to 18 inches diameter, forming a man-hole door; the upper end of this vertical tube forms a reservoir for the steam of the whole twenty-four compartments, and acts as a superheating apparatus, and may be carried up the funnel to the extent necessary to superheat the steam to 400°. The steam-pipe is taken from the top of this boiler to the safety-valve chest, fastened on the front of the boiler low down, which serves as a water-trap during the discharge from the safety-valve chest, the steam-pipe to the engines being taken off the same pipe at a higher level than the escape steam. The spiral compartment, or No. 24, is about 100 feet long, 34 inches diameter, and $\frac{3}{8}$-inch thick, made of the best iron boiler-plate, the ends are conical for 3 feet formed into man-hole doors; this spiral boiler makes four or five convolutions close round the centre one, and is bound close to the circumferential boilers by hollow stay-bolts, and fastened to the centre one at each end only; in the same manner the steam and water flows through the whole boiler by these hollow bolts or rivets, and completes the entire circulation of water and steam. The whole of these 24 compartments or boilers terminate at the bottom about 1 foot below the fire-grate, and are supported on six stanchions from the ash-pit beneath, making a free passage for the air under the grate bar; the circum-

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ferential compartments or boilers terminate at the top 6 feet above the ship's deck, and have each a man-hole door forming the cover; the funnel is made conical at the bottom to embrace the internal diameter of the boiler shell and draw off the smoke in the usual manner. This completes the whole boiler proper, but in order to prevent radiation of heat, a thin outer casing of iron is made (9 inches) clear of the boiler all round, terminating about 7 feet from the stoke-hole floor; and above, at the level of the galley or funnel-house, this casing is lined with felt and thin wood, to keep the deck and the adjacent parts cool, and retain the heat. The twenty-two straight cylindrical boilers or compartments are constructed in the sides by four plates 24 feet long and 16 inches broad, rolled to a 9½-inch radius curve at the iron works, leaving no plate-setting for the boiler-maker of this description.

The plates of boiler No. 24, or the spiral compartment, are delivered flat by the iron-maker, and are bent to the spiral curve by one blow of a large spiral concave block falling upon a counterpart convex one, prepared by the constructors of the boiler. This operation has been found to simplify the making of this spiral cylindrical boiler to about the same amount as the straight cylindrical boilers. The conical ends are bent in the same manner as the spiral plates, and the whole work of plate bending reduced as far as possible to machine work. The products of combustion, after leaving the furnace, have to travel spirally upwards a distance of 100 feet, and must of necessity be continually rotating during that time, and prevent the possibility of any portion passing off without being brought frequently in contact with the heating surface of the boiler, and will therefore be cooled down to the minimum temperature compatible with a given amount of cooling surface, or the greatest quantity of heat extracted from the products of combustion before their escape to the atmosphere.

This spiral coil and all the heating surfaces will keep more clear of flue-dust than usual, and will consequently be more efficient in that respect, as well as save the usual trouble and loss by spunging experienced in the ordinary tubular boilers at sea. Also, as the products of combustion must pass off at the rate of at least 7 feet per second, in this as in ordinary boilers it will take upwards of 14 seconds from the time it leaves the furnace till it arrives at the top of the boiler; whilst if the boiler were of the ordinary tubular type it would pass in about two seconds along the whole heating surface of the boiler; the gas has therefore seven times more time to give out its heat, and its revolving tendency will not admit of the same stratum of gas passing along the passages after it is cooled down, as is the case with the ordinary boiler, but will bring the hot products of combustion usually occupying the centre of the tubes of a tubular boiler into contact with the cooling surfaces, and reduce the whole products of combustion to one temperature before entering the chimney.

In cleaning the salt or sludge out of these boilers the man and sludge hole doors are taken off the top and bottom (and the hose of fresh water may be played down through from the top, and the refuse run out at the bottom). The man in charge can also pass down through the whole boiler; the dimensions necessary for this purpose being made the minimum and maximum of the various compartments of the boiler; and are specially constructed to maintain to the engines steam at much higher pressure than usual, in order to admit of a much larger amount of expansion to be developed by the engines, which are all on the double cylinder expansive principle. The constructors are now making the boilers for three steam-ships on this principle, two of which are for carrying Her Majesty's mails on the Pacific between Valparaiso and Panama (as described by the writer at the meeting of the British Association at Leeds); and it has long been his desire to be able to construct boilers for marine purposes without stays, and with no surface exposed to the collapsing tendency, which in so many cases has been the cause of loss of life aboard of steam-ships. The boilers now described have no large flat surfaces and no stays, the whole tendency of the pressures being to inflate the boiler plates, and, if possible, to give them a stronger form; the smallest diameter is large enough to give access to the men in charge, and the largest diameter is 34 inches, and ⅞-inch thick,—dimensions that can carry several hundred pounds pressure on the square inch before rupture could take place. Such a form the writer adopts with great satisfaction to himself as a constructor sending machinery abroad, where the usual form of boiler gives him considerable anxiety. In comparing the construction of this boiler with that of the ordinary tubular one, in the latter angle-iron ribs and stays now compose a large portion of the weight and expense; contribute no heating surfaces; and if one stay breaks, which is no uncommon occurrence, the next is placed in great danger, and if it gives way the whole may follow in rotation and a serious accident be the result. In the former boiler, however, the plates may be reduced to a very small amount of thickness by tear and wear before explosion could be expected.

Having thus described the objects of the spiral boiler, it might not be out of place to give the following statement of the comparative evaporative power and temperature of the gases in the furnace and chimney of the spiral boiler, with three of the ordinary types of boiler now in general use.

Fig. 1.

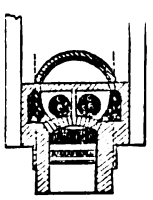


Fig. 2.

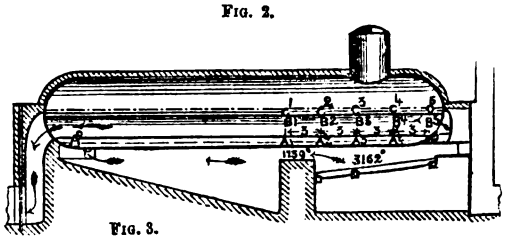
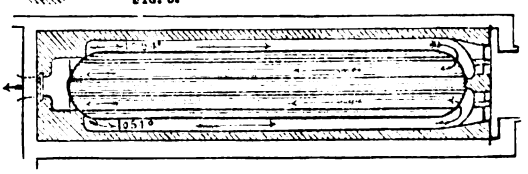


Fig. 3.



The three types experimented upon were, first, a common cylindrical land boiler (Figs. 1, 2, and 3), 33 feet long, 5 ft. 6 in. diameter, with two round flues 19 inches diameter through the centre; this boiler had 40 feet of heating surface to the nominal horse-power of the engine: the two flues contained 20 feet, and the shell 20 feet per nominal horse-power; the furnace was below the boiler at the fore-end, had a fire-grate of 26 square feet, the fire passed underneath the boiler to the opposite end from the furnace, and returned along the sides, and then passed back again through the flues to the chimney. The temperature above the centre of the fire was found to be, on one occasion, 3200°; at the top of the bridge 1730°; the temperature of the gases gradually reduced as they passed back the remaining length of 26 feet under the boiler and along the side flues, till they entered the flues at 1163°, and left them at 800°. Thus the furnace containing a surface of 2 feet per nominal horse-power reduced the heat about 1500°, the shell of the boiler behind the furnace of about 18 feet per nominal horse-power reduced the temperature about 600°, and the flues containing a surface of 20 feet per nominal horse-power reduced the temperature about 350°. The temperatures of the gases in the flues were found to be about the same in the centre as at the top; but at the bottom of the flue the temperatures of the gases were at the fore-end rather less than at the top, but towards the back-end the temperature of the bottom of the flues reduced gradually below the temperature at the top to the extent of 300°. Upon another occasion the temperature over the centre of the fire was found to be 3610°; at the top of the bridge 1739°; and the different temperatures of the flues were as indicated in Fig. 2, where the average temperatures of the flues at $B^1 = 826°$, $B^2 = 879°$, $B^3 = 937$, $B^4 = 959°$, and at $B^5 = 981°$. The temperatures at the top of the flues at $C^3 = 982°$, at $C^4 = 1034°$, at $C^5 = 1087°$. The temperatures at the bottom of the flues at $A^1 = 571°$, $A^2 = 603°$, $A^3 = 678°$, $A^4 = 764°$, at $A^5 = 822°$. It would therefore appear that, notwithstanding the large amount of surface in this boiler, the evaporative power is very inferior, as the amount of heat taken out of the gases per square foot of heating surface is very small; and the natural conclusion is that the gases pass along in straight lines, and only the thin strata in contact with the surface is cooled down. In the results of the spiral boiler (Fig. 6) three times the quantity of heating surface was found to reduce six times the quantity of gas from the same temperature of 3200° to a temperature of 480° instead of 800°, showing that a more complete turning over of the gases is much wanted in our land boilers. The water evaporated per hour in the land boiler referred to was found by meter to be 2000 lb., and the coal, best Glasgow quality, found to be 300 lb. per hour; making about 6½ lb. of water per pound of coal. During the measurement of the water evaporated by the meter, indicator

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diagrams of the engine were taken with a view to calculate the weights of steam by the ordinary method, and the calculations were found to agree with the meter: these calculations can be repeated and substantiated at any time.

The second type of boiler tested was that of the ordinary steamboat horizontal tubular boiler (Fig. 4); the example chosen was one in a first-class ocean steamer. The temperature of the furnace was found to be 3200°, and the inside of the funnel about 1100°. The heating surface of this boiler was 22 feet per nominal horse-power, and the water evaporated about 8½ lb. per pound of coal, according to the calculations from the diagrams. The coal consumed was about 20 lb. per square foot of fire-grate, of the best Glasgow coal.

Fig. 4.

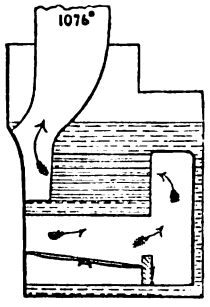
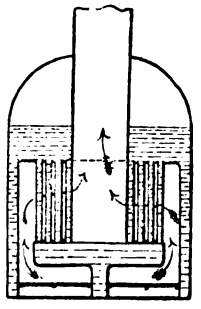


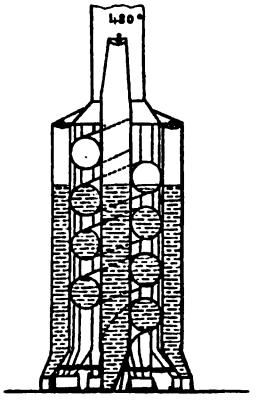
Fig. 5.



The next example taken was that of a first-class vertical tubular boiler (Fig. 5), on Mr. David Napier's principle, now universally liked on the Clyde for river steamers. This boiler had a surface of about 22 feet per nominal horse-power; the temperature of the fire was found to be about 3300°, and in the funnel 1160°; the weight of water evaporated was found by calculation to be 8¾ lb. per pound of coal consumed, and the rate of combustion about 20 lb. per square foot of fire-grate.

In the spiral boiler (Fig. 6) of the San Carlos, Guayaquil, and Prinz van Orange, the boilers were found to give the following peculiar results:—1st, that even with Scotch coal there was no smoke emitted from the chimney, and no carelessness on the part of the fireman seemed to effect the formation of smoke; 2nd, that the boilers showed a bright furnace, indicating first-class draught: the temperature of the funnel was found to be 480° while the fire was at its greatest energy. The heating surface was, in the case of the San Carlos and Guayaquil, 2200 square feet, the coal consumed 1400 lb. per hour, and the water evaporated 11 lb. per pound of coal consumed; the fire-grate contained about 76 square feet, and the rate of combustion about 20 lb. per square foot of fire-grate. The heating surface of the boiler was 18 feet per nominal horse-power; the coal consumed was Glasgow best steam coal. The stoke-hole was found to be remarkably cool, and the boiler, which was loaded to 52 lb. on the square inch steam pressure, and tested to 150 lb. on the square inch water pressure, was found to be perfectly tight. In the case of the San Carlos, I may mention that the ship has now steamed about 20,000 miles, and has not been in any port more than three days; during that time she has been consuming soft Chili coal for a considerable part of her voyage, and the merits of the long flue show a decided advantage in this boiler over the ordinary tubular boiler for the native bituminous coal of South America.

Fig. 6.



In order to give in a more extended form the comparative evaporative power of various flue and tubular boilers, the writer begs to lay before the Association the accompanying table. It shows several proportions of heating surface and evaporative power of several ships that have come under his notice. He can certify the accuracy of most of these particulars, except that shown in the last column, which is taken from Professor Rankine's report on the performance of the Thetis. This vessel has about six times more heating surface in her boilers in proportion to the coal consumed than any example the writer is aware of. The boiler is Craddock's patent boiler, though that inventor's name appears rarely to be mentioned in connection with the said vessel. Efficient, however, as this boiler must be as an evaporator, it cannot possibly accomplish the quantity shown in the table.

The theoretical quantity of water capable of being heated from 90 degrees, and evaporated at, say 212 degrees, with an infinite quantity of heating surface and a perfect fire, is somewhere about 13½ lb. per pound of coal; whilst from the diagrams represented in Prof. Rankine's report of the Thetis' performance, 18 lb. weight appears to be about the quantity of water per pound of coal. This calculation I have made from the diagrams published, and any party interested may repeat the calculations.

The calculation is made as follows:—the area of the large cylinder as shown in the diagram is 1380 square inches, or 9·583 square feet. The four revolutions of piston marked on the diagram, 49½, 52, 53, and 52 revolutions per minute, with a stroke of 2½ feet, or say 258·12 feet per minute, gives 258·12 × 9·583 × 60=146433 cubic feet per hour. And if we take the average pressure shown in the four diagrams at the end of the piston stroke, supposing the barometer to be 14·5 lb., we find the weight of that steam to be about 44 cubic feet per lb.; this number therefore, divided by 44, gives the quantity of steam as 3300 lb. per hour; to this must be added one-twentieth for contents of ports and clearance, which makes 3465 lb. of steam.

This clearly gives the weight of the steam per hour given out of the cylinders after the work is performed; to this therefore must be added the quantity of heat that must have disappeared during the performance of the work, this in the case of the Thetis is about ⅕ of the entire heat; we must therefore add ⅕, or, say 3465+693=4158lb. of water must have been raised from a temperature of about 100 deg. and evaporated, or say 18 lb. of water to the pound of coal said to be consumed. This result is about equal to 20 lb. of water evaporated at 212 deg. to the pound of coal consumed; a quantity quite absurd.

Comparisons of certain Results obtained from Certified Diagrams of Steamers.

	Elk.	Earl of Aberdeen.	Valparaiso.	Pride of Erin.	Inka.	Europa.	Cambrian.	Thetis.
Nominal horse-power	250	380	320	400	80	648	472	80
Indicated ditto	780	780	826	960	272	1207	1072	226
Proportion of indicated horse-power to nominal ditto	3·28	2·05	2·581	2·4	3·8	1·863	2·272	2·82
Diameter of cylinder	57 in.	70 in.	Two 52 / Two 90	72	Two 28 / Two 48	90	77·5	One 21 / One 42
Length of stroke	5 ft. 6 in.	6 feet	5 feet	5 ft. 6 in.	3 feet	8 feet	7 ft. 6 in.	2 ft. 6 in.
Number of strokes per minute ...	25	17·5	24	22	32	15½	16	52
Boilers—flue or tubular ...	Tubular	Flue	Flue	Flue	Flue	Flue	Flue	Craddock's Pat.
Area of fire-grate	144 ft.	190	130	252	50	314	247	...
Area of heating surface ...	4000	4300	2400	4400	480	7000	5400	About 4000
Coals consumed per hour ...	3360 lb.	3584	2520	4928	672	5100	4480	226
Quality of coal	Glasgow best	Newcastle	Welsh	Welsh	Welsh	Welsh	Welsh	Good
Steam evaporated per lb. of coal	7·354	6·87	7·74	7·159	8·1	7·7	7·509	About 15 lb.
Estimate, water evaporated ...	8·1	7·4	8·6	7·9	9·0	8·5	8·3	18 lb.
Coal consumed per I. H. P. ...	4·071	4·385	3·05	5·126	2·47	4·2	4·17	1·018
Fire-grate per nominal H. P. ...	·576	·5	·406	·63	·625	·484	·536	...

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It would therefore appear, before a proper comparison could be established between the merits of the Thetis' boiler and that of any other boiler, a correct trial of the former would be necessary. In the mean time we have but to consider that the report of Prof. Rankine was based on one hour's consumption of, say 230 lb. of coal, and compare that with a mass of boiler, water, and firebrick weighing 20 tons, at a temperature of, say 300 deg., it is evident that the mass of heat in proportion to the coal consumed is so great that no conclusion should be made from such an experiment; also that when the quantity of coal said to be consumed, viz. 230 lb., is compared with area of firegrate, say 40 square feet, it is evident that the result should not be depended upon, as no ordinary comparisons could be made of the condition of the fires before and after the experiment. In conclusion, let me ask of everyone present to consider the trial trips of steamships and boilers in their true light, and before drawing any inference from such trials, make a perusal of results obtained from sea voyages. The evaporative power and economy of boilers is one of the most important subjects for this society to consider. We need only to refer to the report drawn up by the Steam Shipping Committee of the British Association to show how mixed up the question of the relative efficiency of the boilers and engines are generally considered. Indeed, the American navy returns form the only reports showing the evaporative power of the boilers in this list, and the whole merit of a good evaporating boiler is often sacrificed to the character of the engines. With regard to the Thetis I would recommend any mistake to be remedied as soon as possible, as there are many contracts of a most responsible nature formed in consequence of this report, that will lead to serious loss and disappointment to the steam shipping interest and to the engineering profession of this country.

On the Longitudinal Stress of the Wrought Iron Plate Girder.

By CALLCOTT REILLY.

THE theory of the plate girder has been treated by many eminent writers, as Moseley, Hodgkinson, Pole, Tate, and more recently Rankine and Latham. Still experience constrains me to think that it will usefully bear some further discussion, as to the deduction of direct and easy, but at the same time exact, methods of calculations, to be applied in the design of such structures.

Rankine and Latham have treated in a comprehensive manner the theory which shows how the shearing stress is resisted by the middle web of a plate girder, and have shown how to calculate the direction and amount of the diagonal stresses which traverse the web, and that meet and compound with the longitudinal stresses, which are resisted partly by the middle web, and partly by the top and bottom members (or, as I shall call them in this paper, the top and bottom "booms," borrowing the term from the last-named author).

It is the consideration of this diagonal stress which determines in the first place the thickness of the middle plate or web, conjointly with those practical exigencies which demand a minimum thickness of plate to resist the weakening effect of oxidation, and to afford a sufficient bearing for the rivets passing through it.

I shall not touch upon the theory of the diagonal stress, as it is already sufficiently elucidated. The object of this paper is, by an exact analysis of the theory of the longitudinal stress, to deduce, for the use of the engineer, methods of determining the quantity of material required in the booms of the girder to resist any prescribed limits of longitudinal stress, when these limits of tensile and compressive stress are required to be *unequal*, and the resistance to longitudinal stress of the middle web is required to be made the most of, in order to economise the material in the booms. The inequality of the tensile and compressive stress produces a deviation of the neutral axis from the centre of the depth of the beam; and none of the writers I have mentioned, nor any others that I am aware of, have published direct methods of calculation applicable to these circumstances.

The problem usually presented to the engineer who is called upon to design a plate girder, for suppose a railway-bridge, and who by reason of the limited means at his disposal has to make the most of his material, may be thus stated:

Proposition 1.—Given. First: length and depth of girder prescribed generally by the local circumstances. Second: the moment of the resultant of all the external forces applied to the beam by its load and its own weight, acting in the direction at right angles to any plane of section traversing the beam at right angles to its longitudinal axis and its plane of elevation. This moment is determined for any given position of the plane of section by the theory of parallel forces, and it will be denoted thoughout this paper by the symbol M. Third: the thickness of the vertical web determined by the considerations before mentioned. Fourth: the maximum limits, which ought to be unequal, of the longitudinal tensile and compressive stress upon any part of the booms or web of the girder, when bearing its maximum load; and taking into consideration the value of the middle web in resisting a part of these stresses.

The preceding being the given terms of the problem, it is required to determine the net areas of the top and bottom booms, to satisfy these conditions of load and stress.

In the following analysis of this problem only those steps of the demonstrations are assumed for which a reference can be had to writers of known authority.

With reference to the final result I may here state that in all cases equations (7) and (8) may be taken as a first approximation, and for most ordinary cases will be exact enough without going further. When, however strict exactness is desirable, as in very important structures, or if it is desired to ascertain the limits of error, the approximate data derived from equations (7) and (8) may be applied to the solution of the proposition 2, by adopting the exact results exhibited in equations (15) to (16).

To obtain a first approximation the extreme upper and lower fibres of the beam may be assumed to coincide with the centres of gravity of the top and bottom booms. Also the material in the booms may be assumed to be concentrated in the planes of their centres of gravity; and the vertical distance between these may be called the depth of the beam.

The error involved in these assumptions is investigated in the 2nd proposition.

Suppose the beam to be horizontal in position, and to be traversed anywhere by a vertical plane of section at right angles to its longitudinal axis; then with reference to this section, let

a_1=area of the boom subject to tension;

h_1=distance of its centre of gravity from the neutral axis;

a_3=area of that portion of the middle web subject to tension, that is that portion whose depth is h_1;

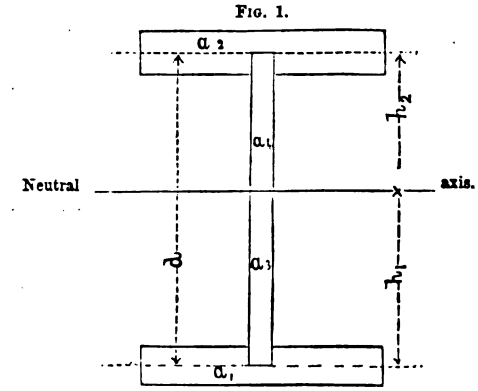
f_1=limit of tensile stress per square unit (say per square inch) on those fibres whose distance from the neutral axis $=h_1$;

I_1=moment of inertia of the surface whose area is a_1+a_3, with respect to the neutral axis;

And let a_2, h_2, a_3, f_2, and I_2 refer to the corresponding quantities under compression.

To determine the position of the neutral axis a_1 and a_2 being unknown. It may be assumed as proved for wrought iron, that within the limits of elasticity, the material is compressed and extended through equal distances by equal intensities of stress, and therefore at equal distances from the neutral axis tensile

FIG. 1.



and compressive stresses per unit of area are equal; and moreover the sum of the compressive resistance of the material on one side of the neutral axis must be exactly equal to the sum of the tensile resistances on the other side; and therefore the neutral axis passes through the centre of gravity of the plane of section. Also, according to Hooke's law, the stress upon the fibres, whether compressive or tensile, is directly proportional to

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their distances from the neutral axis. (See Tate's 'Strength of Materials,' art. 2 to 6 and 12.)

Whence, if s = stress (either compressive or tensile) per square inch at distance unity from the neutral axis, and d = depth between centres of gravity of the booms:

$$f_1 = sh_1 \quad f_2 = sh_2 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$\text{or, } \frac{f_1}{f_2} = \frac{h_1}{h_2} \qquad h_1 = \frac{f_1}{f_2} h_2 = \frac{f_1}{f_2}(d - h_1) \text{ for } h_1 + h_2 = d;$$

$$\text{or } h_1(f_1 + f_2) = f_1 d$$

$$\therefore\ h_1 = \frac{f_1 d}{f_1 + f_2} \text{ and } h_2 = d - h_1 \quad \ldots \quad \ldots \quad (2)$$

which fixes the neutral axis.

a_3 and a_4 are known at once, for

$a_3 = h_1 \times$ thickness of middle web

$a_4 = h_2 \times$ thickness of middle web.

To find the areas of the booms a_1 and a_2. It can be shown (see Tate's 'Strength of Materials,' art. xvii.) that

$$M = s(I_1 + I_2) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Substituting the usual expressions for the moments of inertia,

Approximate moment of inertia of $a_1 = a_1 h_1^2$

" " " $a_2 = a_2 h_2^2$

Exact " " $a_3 = \frac{1}{3} a_3 h_1^2$

" " " $a_4 = \frac{1}{3} a_4 h_2^2$.

$$\text{Then, } \left.\begin{aligned} I_1 &= a_1 h_1^2 + \tfrac{1}{3} a_3 h_1^2 \\ I_2 &= a_2 h_2^2 + \tfrac{1}{3} a_4 h_2^2 \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

$$\therefore\ M = sh_1(a_1 + \tfrac{1}{3}a_3)h_1 + sh_2(a_2 + \tfrac{1}{3}a_4)h_2$$

By equation (1) $sh_1 = f_1$, $sh_2 = f_2$; hence

$$M = f_1 h_1 a_1 + \tfrac{1}{3} f_1 h_1 a_3 + f_2 h_2 a_2 + \tfrac{1}{3} f_2 h_2 a_4$$

$$\therefore\ \left.\begin{aligned} f_1 h_1 a_1 + f_2 h_2 a_2 &= M - (\tfrac{1}{3} f_1 h_1 a_3 + \tfrac{1}{3} f_2 h_2 a_4) \\ &= M - N \text{ (suppose)} \end{aligned}\right\} \quad \ldots \quad (5)$$

In equation (5) the only unknown quantities are a_1 and a_2, and to complete the solution another independent equation between them is necessary. This may be derived as follows: from the assumption previously made of the principle of equal resistances on each side of the neutral axis which passes through the centre of gravity of the section, we deduce that the sum of the moments of the areas on one side the neutral axis must be exactly equal to the sum of the moments of the areas on the other side; that is, $a_1 h_1 + \frac{1}{2} a_3 h_1 = a_2 h_2 + \frac{1}{2} a_4 h_2$, or,

$$a_2 h_2 - a_1 h_1 = \tfrac{1}{2} a_3 h_1 - \tfrac{1}{2} a_4 h_2 \quad \ldots \quad \ldots \quad (6)$$

This equation is independent of equation (5), which gives $f_1 h_1 a_1 + f_2 h_2 a_2 = M - N$. By equation (6), $f_2 h_2 a_2 = f_2(\frac{1}{2} a_3 h_1 - \frac{1}{2} a_4 h_2 - a_1 h_1)$. Substituting this value of $f_2 h_2 a_2$ in equation (5) we get

$$f_1 a_1 h_1 + f_2(\tfrac{1}{2} a_3 h_1 - \tfrac{1}{2} a_4 h_2 + a_1 h_1) = M - N;$$

or, substituting for N its value from (5),

$$a_1 h_1 (f_1 + f_2) = M - h_1 a_3 (\tfrac{1}{3} f_1 \times \tfrac{1}{2} f_2) + \tfrac{1}{6} f_2 h_2 a_4:$$

$$\therefore\ a_1 = \frac{M - h_1 a_3 (\frac{1}{3} f_1 + \frac{1}{2} f_2) + \frac{1}{6} f_2 h_2 a_4}{h_1 (f_1 + f_2)} \quad \ldots \quad \ldots \quad (7)$$

whence a_1 is known, and substituting the numerical value of a_1 determined by the preceding in equation (6), we have

$$a_2 = \frac{\frac{1}{2}(h_1 a_3 - h_2 a_4) + a_1 h_1}{h_2} \quad \ldots \quad \ldots \quad (8)$$

therefore a_2 is known.

These expressions for a_1 and a_2 admit of easy and rapid numerical computation, because, although they contain many terms, these are all of the first degree, and excepting a_1, a_2 and M, they are all constant for every section of the same girder, unless the latter be large enough to render it expedient to economise material by making the thickness of the middle web less in the centre of the girder than at the ends; this of course supposes the depth of the beam to be constant throughout its whole length. The method of proceeding is as follows: the depth of the beam being fixed by the local circumstances, divide the length between the bearings into parts more or less numerous according to the accuracy of the results required; calculate the value of M according to the theory of parallel forces for each cross section at these divisions, fix the thickness of vertical web as thin as the considerations before mentioned will allow. It is generally considered that if plates in single thicknesses—as in the web of a girder—less than $\frac{1}{4}$-inch thick, are exposed to atmospheric influences, they soon become injured by oxidation, as to their capability to resist stress, unless the skin of paint is maintained in a sound condition. Then by substituting the numerical value of M for each cross section successively, the corresponding values of the areas of the top and bottom booms are determined by equations 7 and 8 for any given limit of stress. One or more of these results should then be verified by the method investigated in proposition 2, and if very accurate results are required the corrections indicated by equation 16 may then be applied.

With regard to the values of f_1 and f_2, it is proved by the experiments of Mr. E. Hodgkinson and others (see report of the Iron Commission), that the ultimate tensile strength of wrought iron of average quality is 20 tons per square inch, and the ultimate resistance to crushing does not exceed 15 tons, and seems very variable: if then $\frac{1}{4}$th the ultimate strength is considered a safe limit of working stress we should have as suitable values

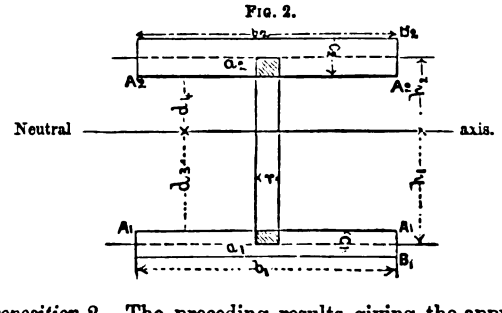
$f_1 = 5$ tons per square inch.

and $f_2 = 3\frac{3}{4}$ " "

supposing the plates under compression protected from buckling by their safe proportion of thickness to unsupported surface.

Investigation of error and method of verification.—The results given by equations (7) and (8) are exactly true only under the assumption stated, namely, that the booms are without thickness, their material being supposed to be concentrated in the planes of their centres of gravity. This produces an error which is of no material consequence when the booms are thin in comparison with their breadths and the depths of the girder, and is, moreover, on the safe side, giving stresses greater than actually occur in the real girder, having the proportion of its cross section determined by the preceding. The error is only worth correction when the booms have a thickness exceeding considerably, say $1\frac{1}{2}$ inch, as it is only then that the cube of the thickness which is in direct proportion to the error rapidly increases; it is also of some consequence when the booms have a compound form, such as the box shape. In all such cases it is best to use the preceding method as a first approximation, and then after determining the figure of the cross sections, to verify the computed results in equations 7 and 8, at the same time applying the corrections to be determined by the following analysis of the conditions which govern the error in question, and which are exhibited in the solution of the next proposition.

FIG. 2.



Proposition 2.—The preceding results giving the approximate areas of the booms to resist the stresses f_1 and f_2, for a prescribed depth between their centres of gravity and a prescribed thickness of vertical web; it is required to determine the exact stresses, say F_1 of tension and F_2 of compression, on the fibres in the same planes of centres of gravity of the booms; the cross section of the girder taken at any given point having the figure determined by the preceding results.

The thickness and breadth of the booms having been determined by the local circumstances, so that the areas a_1 and a_2 remain as fixed by equations (7) and (8), we find that in order to preserve the same areas and thicknesses these breadths require a correction, on account of the theoretical assumption made in Prop. 1, that the depth $h_1 + h_2$ between the centres of gravity of the booms is the same as the depths of the vertical web; but now that we take the thicknesses of the booms into the account, the depth of the web becomes less than $h_1 + h_2$ by half the sum of those thicknesses. Now it is necessary by the proposition that the figure and area of the cross section remain unaltered (see Fig. 2). Therefore

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just so much as is cut off the area (above and below the neutral axis) of the web by the inner edges $\overline{A_1A_1}$, $\overline{A_2A_2}$ of the booms must be added to the original values of a_1a_2, the area of the entire cross section of the girder and the position of its neutral axis then remain as determined by the first proposition. The shaded parts in the diagram illustrate this, showing the portions taken from a_3 and a_4, and added severally to the original values of a_1 and a_2.

The corrected value of a_1 is now the area of the rectangle $\overline{A_1B_1}$
" " a_2 " " $\overline{A_2B_2}$
" " $a_3 = rd_3$
" " $a_4 = rd_4$
" depth of web under tension $= d_3$
" " compression $= a_4$
" thickness of web " $= r$
" " of booms $= c_1$ and c_2 respectively
" breadth " $= b_1$ and b_2 "

The neutral axis passes through the centre of gravity of the section (see Prop. 1); and by the equality of moments we have, assuming the line passing through the centre of gravity of the boom $\overline{A_1B_1}$ as the axis of moments, and h_1 as the distance of the neutral axis from this axis,

$$h_1 = \frac{a_2(h_1+h_2)+(a_3+a_4)\frac{d_3+d_4+c_1}{2}}{a_1+a_2+a_3+a_4} \quad \ldots \quad \ldots \quad (9)$$

which should verify the computation by equation (2).

Proceeding now to the solution of F_1 and F_2, let

I_1 = moment of inertia with respect to the neutral axis of the area a_1
I_2 = " " " " " a_2
I_3 = " " " " " a_3
I_4 = " " " " " a_4

The moment of inertia of the surfaces under tension is therefore I_1+I_3, and of the surfaces under compression is I_2+I_4, and (see equation 4) the exact expressions for I_3 and I_4 are

$$I_3 = \tfrac{1}{3}a_3d_3^2, \quad I_4 = \tfrac{1}{3}a_4d_4^2 \quad \ldots \quad \ldots \quad (10)$$

while the approximate values of I_1 and I_2 are determined by the expressions

$$I_1 = a_1h_1^2, \quad I_2 = a_2h_2^2 \quad \ldots \quad \ldots \quad (11)$$

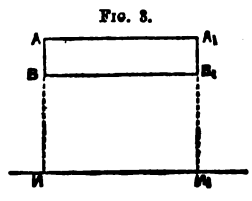
The numerical calculation for the exact value of I_1 and I_2, which is exhibited in a general form in equation 12, being considerably more laborious than equation 11, which gives results in defect of the truth and therefore on the safe side, it is convenient to calculate first by 11, and then to apply to the result a correction the expression for which is deduced by the lemma below, equation 13. As we shall see, the difference between the above approximate and the exact results is so small that the correction need only be applied when the thickness of the booms is comparatively great. When the booms have a hollow or box shaped section, it may be easiest to determine I_1 and I_2 by the exact formula, equation 12.

LEMMA.

In the annexed diagram (Fig 3), let the rectangle $\overline{AB_1}$ represent the section of either boom of the girder, its outer edge $\overline{AA_1}$ having the distance D from the neutral axis $\overline{NN_1}$, and its inner edge $\overline{BB_1}$ the corresponding distance d. It is required to determine the error developed by the use of the equation $I = ah^2$, which is of the form of the preceding equations (11), the quantities having the same values as there used, and being unaccented, apply to the parts under either compression or tension.

Let K = area of rectangle $\overline{AA_1N_1N}$,
k = " " " $\overline{BB_1N_1N}$;
as before a = area of rectangle $\overline{AB_1}$,
" c = its depth $\overline{AB}$,
" b = its breadth $\overline{AA_1}$.

Fig. 3.



Then the exact value of I is determined by the expression (see Tate's 'Strength of Materials')

$$I = \tfrac{1}{3}(KD^2 - kd_2) \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

Now the error in question is the difference between ah^2 and $\frac{1}{3}(KD_2 - kd^2)$. But

$$ah_2 = bc(d+\tfrac{1}{2}c)^2 = d^2cb + dc^2b + \tfrac{1}{4}c^3b,$$

and $\frac{1}{3}(KD^2 - kd^2) = \frac{1}{3}[(d+c)^3 - d^3]b = d^2cb + dc^2b + \frac{1}{3}c^3b$

$$\therefore \tfrac{1}{3}(KD^2 - kd^2) - ah^2 = \tfrac{1}{3}c^3b - \tfrac{1}{4}c_3b = \frac{c^3b}{12} \quad \ldots \quad (13)$$

whence the error in question varies as the breadth b, and the cube of the thickness c; and the approximate expression $I = ah^2$ in equation (11) becomes exact by the addition of $\frac{1}{12}c^3b$. Hence

$$\left.\begin{aligned} I_1 &= a_1h_1^2 + \tfrac{1}{12}c^3b_1 \text{ exactly} \\ I_2 &= a_2h_2^2 + \tfrac{1}{12}c_2^3b_2 \quad " \end{aligned}\right\} \quad \ldots \quad \ldots \quad (14)$$

Now, equating the sum of all the moments of inertia with the known value of M for the given position of the plane of section, and substituting from equations (10) and (14) we have by equation (3)

$$M = s(I_1+I_2+I_3+I_4) \quad \ldots \quad \ldots \quad (14a)$$

$$\therefore s = \frac{M}{a_1h_1^2 + a_2h_2^2 + \frac{1}{3}(a_3d_3^2 + a_4d_4^2) + \frac{1}{12}(c_1^3b_1 + c_2^3b_2)} \quad \ldots \quad (15)$$

and s being the stress per square inch at distance 1 inch from the neutral axis, the reasoning of equation (1) proves that

$$F_1 = h_1s \quad F_2 = h_2s \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

which is the solution of the proposition; F_1 and F_2 being respectively the stresses in tons per square inch of tension and compression at distances h_1 and h_2 from the neutral axis, that is, at the centres of gravity of the booms; the units of quantity throughout being inches and tons. In those frequent cases where the thickness of the booms is inconsiderable, and therefore the error investigated above of no material consequence, the results given by equations (7) and (8) may be verified by equations (9) and (15), omitting from the denominator of the second side of (15) the factor $\frac{1}{12}(c_1^3b_1 + c_2^3b_2)$ and inserting in the same expression the original values of a_3 and a_4, and the values of a_1 and a_2 resulting from equations (7) and (8) without the corrections discussed in the last proposition. The results in equations (16) should then be the original values of f_1 and f_2, instead of F_1 and F_2.

On the effect of assuming the equality of the ultimate resistance of the material to compressive and tensile stress.—This assumption though unphilosophical is often employed in practice, as it simplifies considerably the numerical calculations; and where time for the preparation of the design is so imperatively restricted as to present a gain counterbalancing the waste of the material occasioned by assuming the tensile resistance too low, such considerations may have their value: but they should only be allowed to prevail in small and unimportant structures. The unphilosophical character of this assumption is evident from the experiments of Mr. Eaton Hodgkinson and others, previously alluded to, which showed conclusively that the ratio of ultimate compressive to ultimate tensile resistance never exceeds 4 to 5, and is only as great as this under circumstances most favourable to the former, namely, when the conditions which govern the law of pillars are entirely eliminated from those parts of the structure resisting compression by careful adjustment of sufficient stiffening.

Assuming the foregoing circumstances, it is proposed to examine how the preceding theory and formulæ are affected. Recurring to proposition 1, we see at once that f_1 and f_2 being assumed equal, the section of the girder, as to its figure, is symmetrical about its neutral axis.

Therefore let

$$f_1 = f_2 = f \qquad a_1 = a_2 = a$$
$$h_1 = h_2 = \frac{d}{2} \qquad a_3 = a_4 = \frac{w}{2}$$

w = entire area of web; d = as before depth between centres of gravity of the booms = entire depth of web.

Substituting these altered values of the symbols in equation (5) we have

$$afd = M - \frac{dfw}{6}$$

solving this equation with respect to a, we have for the area of either top or bottom boom

$$a = \frac{M}{fd} - \frac{w}{6} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

or solving with respect to f, we have for the stress at the centre of gravity of either boom

$$f = \frac{M}{d(a+\frac{1}{6}w)} \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

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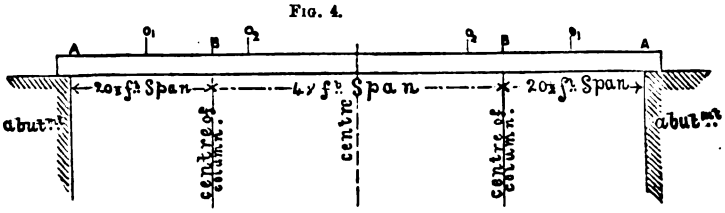
These two results coincide with those given by Mr. Pole in Clarke's 'Britannia and Conway Bridges.'

The following example of the economy of material that may be secured by attention to the foregoing principles is the case of a bridge built within the past year from designs based on this method of calculation.

The economy of material exhibited, as compared with the local requirements, is no doubt due principally to the continuity of the beams over the intermediate bearings, but also partly to a careful application of the preceding principles.

The bridge carries a turnpike road over a railway having four lines of way on a considerable skew; the clear distance between abutments being 82 feet, exclusive of the bearings on the top of the intermediate columns, which is two feet more, making 84 feet in all. The headway being limited and the earthwork approaches heavy, required a small depth only between the surface of the metalling and the soffit of the girders. Free access for examination and painting of every part of the girders (excepting the top surface next the metalling, which is covered with

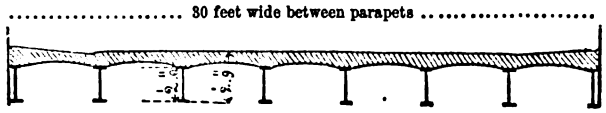
Fig. 4.



a thickness of asphalte) was exacted, as also a due economy of material. These conditions were complied with; and the total weight of girders only, including all joints and stiffening, for a clear width between parapets of 30 feet, and a live load of 1·4 cwt. per square foot of roadway surface, in addition to the total dead load of 1·1 cwt. per square foot, both uniformly distributed, is only 23 tons, wrought iron being the only material used; this weight divided by the length of clear distance between abutments is less than 0·28 ton per foot of span.

The annexed diagrams illustrate the dimensions of this example. Fig. 4 is a side elevation of girder, and Fig. 5 a cross section of girders and roadway.

Fig. 5.



It is observed that the roadway and parapets are carried by eight plate girders 2 feet deep, continuous over three openings, the two side spans being 20½ feet each, the middle span 41 feet, without reckoning the width of the iron columns that carry the intermediate bearings. The metalling is carried by Mallet's buckled plates which are rivetted to the top booms of the girders.

For the purposes of calculation, as the eight girders are to be all alike they may be supposed to be combined into one theoretical girder—2 feet deep between the centres of the booms—whose breadth is the sum of the breadths of all the booms of the separate girders, and the thickness of its middle web is the sum of all the thicknesses of the separate webs.

With regard to the middle web, the thickness required theoretically by the diagonal stresses is small as compared with the practical exigencies of durability and the necessity of getting a sufficient bearing surface for the rivets passing through it. If the plates of the web are less than ¼-inch thick they will be liable to injury (if the renewal of the paint is neglected for a short time only in any part) by oxidation; therefore the separate webs are to be ¼-inch thick, which will give sufficient thickness for bearing surfaces on the rivets. It is also proposed to construct the girders of ¼-inch plate throughout, piling them where a greater thickness is required.

The annexed sketch, Fig. 6, shows the net section of the theoretical girder made up of all the real ones in the manner described. The thickness of the booms to vary according to the areas given by the calculations, and the thickness of the middle web constant through the entire length of the beam, and to have its joints so constructed as to enable it to bear its share of the longitudinal stress.

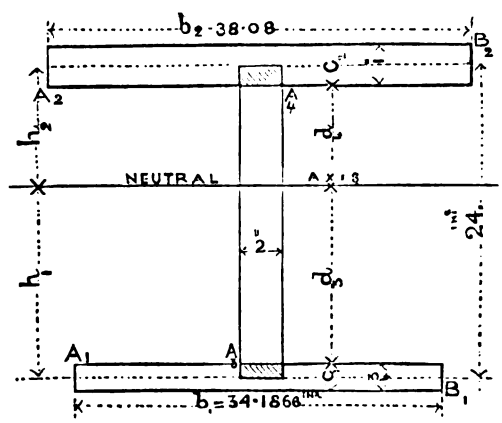
The figure represents Section No. 11 in the table following, at centre of the middle span.

Gross load = 2½ cwt. per square foot of platform surface uniformly distributed.
= 0·3125 tons per inch of the span of theoretical beam.

Reaction of pressure upon each abutment = 16·82 tons.

Ditto each pier or set of columns at B, Fig. 4, =136·93 tons.

Fig. 6.



To determine the areas of booms, according to proposition 1, it is necessary first to calculate the value of M, the moment of longitudinal stress operating upon each plane of cross section taken at the convenient distances from A, Fig. 4, and numbered 1 to 11.

(To be continued.)

Outlines of the Principles and Practice involved in dealing with the Electrical Conditions of Submarine Electric Telegraphs. By Werner and C. W. Siemens.

The failures of the more extensive lines of submarine electric telegraphs, which have hitherto been but too frequently experienced, have become manifest almost invariably by a gradual decrease of insulation. In repairing these lines it has generally been found that the gutta-percha has become disintegrated by the electrolytic action of the currents employed in working the line in places where the thickness of insulating material had been originally considerably below the average, owing to some mechanical injury or more frequently owing to a cavity in the material forced into by the water, or to an eccentric position of the conductor.

In such places where the insulating covering of gutta-percha has been of uniform and sufficient thickness, no disintegration or partial destruction of the material is observable even after the line has been worked for many years. The rapidity with which the work of destruction in faulty places proceeds depends entirely upon the intensity and duration of currents employed in working the line. Faults are produced proportionately more rapidly in long lines, owing to the greater resistance of the metallic conductor. Their progress can be retarded in working the lines with feeble and alternating currents, but it cannot be arrested entirely; and it may be laid down as an axiom that, *so long as any thin places are allowed to remain in the gutta-percha covering of a submarine conductor, so long will their insulation fail by slow degrees.*

It is therefore a matter of first importance to prevent, if possible, all irregularity in the insulating covering. The material employed should be perfectly homogeneous; it should be put upon the wire in several coatings closely adhering to one another; air-bubbles should be strictly avoided, and the concentricity of the entire coating be insured by the use of very perfect machinery and strict avoidance of stoppages during the process of covering, to prevent a softening of the several coatings by heat.

Great improvements have of late been effected in the process of covering electric conductors with gutta-percha and intermediate layers of compound called "Chatterton's mixture," which may be estimated by the fact that the covering of the Rangoon and Singapore cable now in process of manufacture insulates

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fully ten times better than the covering of the Red Sea and India cable did before it was laid.

This marked improvement is due to the greater care taken by the Gutta-percha Company in the manufacture, under a system of stringent electrical tests which we are charged by the British government to apply. The object of these tests is, in the first place, to ascertain the specific conductivity of each mile of the copper conductor, in order that all below a certain fixed standard may be rejected.

An inquiry into the extraordinary variations in the conductivity of the copper of commerce has been made the subject of a careful investigation by Dr. Mathiessen for the British government, which will probably be shortly published.

In practice we find that the best selected copper employed for telegraphic conductors varies as much as twenty per cent. in its conductivity, and that the purer copper conducts the best.

The conductivity tests of each mile of an insulated conductor are very necessary, not only to reject the faulty material but also to obtain a complete record of the conductivity of each portion of the cable when completed, without which it is not possible to determine afterwards by galvanic tests and calculations the precise position of a fault. The more difficult and most important tests are those of the conductivity of the insulating material of each mile of insulated conductor, for it is not sufficient to find out any palpable fault or leakage, but to appreciate eccentricities, cavities, or other minor defects in the coating, and to reject what falls below the standard of conductivity of the insulating material in its most perfect condition. It was necessary for this purpose to determine in the first place the specific conductivity of the material, which experience has proved to be sufficiently uniform at constant temperatures.

The effect of temperature upon the conductivity of gutta-percha and other insulators has lately been fully investigated by the scientific Telegraph Committee of the British government, whose report is however not yet published. It suffices for our present purpose to state that between the limits of 41° and 80° Fah. we found the conductivity of the insulating covering of the Rangoon and Singapore cable to increase nearly in the ratio of 1 : 7. The ratio of this enormous increase is however by no means constant; and in the absence of very elaborate and reliable experimental results, we thought it advisable to test at a uniform temperature of 75° Fah. (20° Cent.). This comparatively high degree of temperature has the advantage that it is seldom exceeded naturally, and that the conductivity being seven times greater at that temperature than at the winter temperature of 41°, the effect of minute faults upon the measuring instrument will also be proportionately exaggerated.

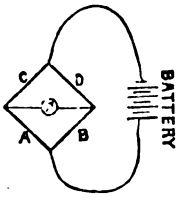
In order to insure uniformity of temperature the coils to be tested are placed 24 hours into tanks containing water regulated to 75°, they are then removed into the testing tank of the same temperature, which is hermetically closed, and hydraulic pressure of at least 600 lb. per square inch applied, in order to force the water into the cavities or fissures that may present themselves. It is a remarkable fact, which is borne out by observations upon cables in process of submersion, that the application of hydrostatic pressure sensibly decreases the conductivity of gutta-percha, which however increases again slightly above the former ratio when the pressure is relieved. In slightly defective coils the increase of external pressure produces, on the contrary, no increase or even decrease of insulating property, and a clue is thus obtained to ascertain otherwise inappreciable defects. The methods usually employed of measuring the conductivity and insulation of conductors in degrees by simple galvanometer tests would be insufficient for the purposes here intended. It was necessary to express the conductivity of both the conductor and the insulating covering by simple numerical expression in units of resistance.

The unit of resistance we have adopted is that of a column of mercury, 1 metre in length, and of 1 square millimetre sectional area, taken at the freezing point of water. The advantages of this unit have been fully set forth by Mr. Werner Siemens in a treatise published in 'Poggendorff's Annalen,' vol. 110.

In expressing the degrees of conductivity of both the wire and the insulating medium in definite units of resistance, we obtain not only the advantage of a more accurate comparison between the results of different indication, but subsequently, when the separate coils are united with a single cable, we have an admirable means of judging its electrical condition if we compare the total resistances of both the conductor and the insulating medium with the sum of the resistances previously obtained in testing each coil separately, due allowance being made of course for change of temperature. But the principal advantage derived from this system of measuring consists in the facilities it affords in determining the position of a fault in the cable while it is being laid and after submersion.

In carrying this system into practice we construct in the first place coils of definite resistance, which are capable of being combined in such a manner that we can vary the total resistance between the limits of 1 unit and 10,000. By inserting these alterable resistances into one branch of a Wheatstone's bridge, the resistances of the copper or insulating covering of a cable of considerable length can be ascertained. If, however, it is required to ascertain resistances beyond the limits of the resistance coils, we adopt another arrangement on the principle of the Wheatstone's bridge, which consists in making the two permanent branches of the same also changeable.

A, B, C, D, represent the four branches of this arrangement, A C and B D being in connection with the galvanometer, A B and C D the terminals of a battery. No current will pass through the instrument when the relation of $\frac{A}{B} = \frac{C}{D}$ exists. But as in Wheatstone's arrangement A is always equal to B, the unknown resistance D is equal to the resistance C. A scale containing resistance coils from 1 to 10,000 units, would therefore only allow us to ascertain resistances not exceeding these limits; but C and A being each composed of three variable coils of 10, 100, and 1000 units respectively, we are enabled to measure any resistance between 0·01 and 1,000,000 units with the same degree of accuracy. By means of this arrangement we measure the resistances of copper wire of any length, and the insulation resistance of long cables within the limits of correctnes of 0·2 per cent.



For the insulation tests of short pieces of cable or of longer cables of better insulating materials, such as india-rubber and Wray's mixture, such method is no longer applicable, because resistance coils of such diversity of dimensions as would be necessary could not be used with sufficient accuracy, chiefly because the greater battery power that would be required would heat the smaller branches of the arrangement, and, thus increasing their resistance, affect the result very considerably.

It was necessary therefore to turn to another method for ascertaining the value in units of the insulation resistances of short pieces of cable, say one knot in length. We employ in such cases a very sensitive sine-galvanometer, or, if the room permits of it, a Weber's reflecting galvanometer of 40,000 turns and a magnetic reflector. By means of an adjusting magnet the sensibility of this instrument can be varied between the limits of 1 and 100. The astatic condition of the needles of the sine-galvanometer being subject to changes, the constant of the instrument should be verified repeatedly while testing. For the readings of this instrument in degrees we substitute units of resistance by means of the following formula:

$$R = \frac{\sin \phi_1}{\sin \phi} n \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

in which R is the insulation resistance; ϕ the angle of deflection; $\sin \phi_1$ the constant of the instrument; n the number of elements employed. For the derivation of this formula see Appendix No. 1.*

This method is applicable only for measuring great resistances between certain narrow limits.

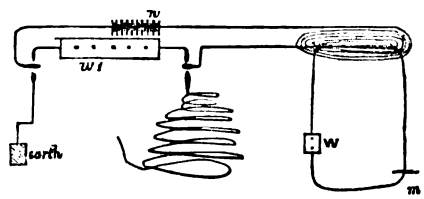
During the progress of the cable at the sheathing works the insulating resistance gradually decreases, and the instrument would very soon be too sensitive. It could be made less sensitive, it is true, but in resorting to this it would no longer be possible to appreciate correctly the value of the resistance of the last coil added to the cable. It was therefore necessary to resort to a means of maintaining the original degree of sensitiveness of the measuring instrument, while the total resistance gradually decreases. For this purpose the coils of the sine-galvanometer employed are surrounded by an additional coil of comparatively few turns, through which the current of a constant small battery

* The appendix will be given in our next.

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continually passes. The insulation current passes through the wire of the instrument, but is counteracted by the current in opposite direction in the outer coils, which is so regulated by means of a resistance coil that no deflection of the galvanometer needle can be observed.

In adding to the length of the cable, the resistance coil in the outer circuit of the instrument has to be diminished by stopping till the equilibrium of the needle is restored; and the value of the alteration of the resistance coil being known in units, this number has only to be multiplied by the fixed proportion of the relative power of the outer and inner coil upon the needles to produce the correct result.



If W represent the resistance of the inner coil; W_1 the resistance coil put into the inner circuit; m the number of cells of the battery of the inner circuit; w the resistance of outer coil; w_1 the resistance coil put into the outer circuit; n the number of cells of the outer battery circuit; and K the number indicating the proportion of the effect of the outer and inner coil on the needle; we have

$$\frac{n}{w+w_1} K = \frac{m}{W+W_1}, \text{ or } K = \frac{m(w+w_1)}{(W+W_1)n}$$

If, instead of W_1 the unknown resistance of the cable is introduced into the circuit by arranging the resistance w till the needle is perfectly at zero, the following equation is established:

$$\frac{m}{x+W} = \frac{n}{V+w} \cdot K, \text{ or } x = \frac{M(V+w)}{N \cdot K} - W$$

or by introducing for K its value from above,

$$x = \frac{Mn}{Nm} \frac{W+W_1}{w+w_1} (V_1+w) - W.$$

The chief advantage of this arrangement consists in the unchanged sensibility of the instrument, since the whole strength of the insulation current acts upon the needle, which nevertheless is brought back always to zero. In measuring the insulation resistance of short cables the resistance of the galvanometer coils w and W_1 may in practice be neglected, and the following more simple formula be adopted:

$$x = \frac{M}{N} \cdot \frac{V}{K} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

The value of K is independent of the sensibility of the needle, and need only be determined once for all. The tests are thus reduced to a very simple and easy method.

In order to calculate the insulation resistance of insulated wires from the specific conductivity of the material used, and vice versâ, we employ the following formula:

$$W = \frac{C \log \text{nat.} \frac{R}{r}}{2\pi l \lambda} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

The derivation of this formula has been given by Mr. Werner Siemens in 'Poggendorff's Annalen' of 1857, vol. 102, and will be found in Appendix No. 2 of this paper.

The foregoing methods suffice to ascertain insulation and copper resistances of cables of all lengths and forms; they do not comprise however the test necessary to determine their inductive capacities.

Recent experiments, hereafter given, prove that the specific inductive capacity of the insulating materials is more to be relied upon for permanency than their specific conductivity; the inductive capacity is, moreover, independent of local defects in the insulating covering, being dependent chiefly upon the general geometrical form of the insulator. In ascertaining therefore the inductive capacity of a length of cable as compared with a standard Leyden jar, and in comparing this result with the total capacity due to the material employed, a means is obtained of ascertaining with great certainty whether the material is disposed throughout its length in equal thickness round the conductor, or whether the wire lies partly eccentric. A knowledge of the inductive capacity of a cable is moreover absolutely necessary in order to determine the position of a break in the conductor when the broken end remains insulated.

According to Faraday's conception the inductive action is communicated, say from the interior electrified covering of a Leyden jar to the exterior, from atom to atom through the dialectric. In our case the jar is represented by the cable, the inner covering of which is formed by the surface of the copper wire, the exterior by the water.

The laws which apply to the motion of heat and electricity in conductors are accordingly directly applicable to electro-induction, which may be expressed by the conductivity multiplied by a constant varying with the nature of the insulating material.

Starting from this point of view the inductive capacity of any insulated wire will be represented by the formula

$$K = \frac{IC \cdot 2\pi l}{\log \text{nat.} \frac{R}{r}} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

In which the inductive capacity I takes the place of the specific conductivity λ of the previous formula. The unit measure of inductive capacity is assumed to be the capacity of a Leyden jar of two square plates of the unit of measure in breadth and placed at the same distance apart.

Professor W. Thomson has obtained the same formula in a direct and most elegant manner, which differed from that of Mr. Werner Siemens' in the value of the constant, proving that he started with another unit. Mr. Werner Siemens' method has been fully developed in 'Poggendorff's Annalen,' vol. 102.

In dealing with cylindrical jars or with cables this formula may be written more simply thus:

$$K = C \frac{I \cdot C}{\log \text{nat} \frac{R}{r}}$$

In our experiments the inductive capacity of a Leyden jar is measured by the deflection of a galvanometer needle. If the deflection of the needle is caused by a current of very short duration, the quantity of the electricity passing through the galvanometer is equal to

$$K = \frac{\sin \frac{A}{2}}{E}$$

In practice it is found to be very difficult to read with sufficient accuracy the sudden deflection of a needle, and we prefer for practical use an instrument which we have placed before the Section, enabling us to obtain a rapid succession of charging or discharging currents, which, in passing through the galvanometer, produce a steady deflection of the needle capable of being read with great accuracy. The value of these deflections is calculated by means of the following formula.

If A is the angle through which the sine-galvanometer has to be turned to bring the needle to zero, C the number of charges or discharges per second, E the electro-motive power of the battery; we have

$$K = \frac{\sin A}{E} C *$$

Or if K_1 is the unit capacity of a jar, and A the corresponding angle of readjustment of the instrument, we have (if the number of discharges per second remains the same),

$$K : K_1 = \sin A : \sin A_1$$

$$K = \frac{K_1 \sin A}{\sin A_1}$$

By permission of the British government we have been enabled to test the government experimental cables by this method. The results of these experiments, which are given in the table of Appendix No. 3, show satisfactorily the accuracy of the methods employed. They also prove that the formula employed in calculating the specific inductive capacities, which Prof. W. Thomson

* In this case the amount of charge is represented by a constant deflection, and therefore by $\sin a$; whilst above, where it was given by one swing of the needle, it is equal to $\sin \frac{A}{2}$.

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and Mr. Werner Siemens obtained in entirely different ways, can be relied upon in practice:

The specific induction of all gutta-percha covered wires is shown to be nearly the same, and to be entirely independent of its specific conductivity, while india-rubber and its compounds are far inferior in specific induction to gutta-percha. The specific induction of gutta-percha being taken as a unit, that of india-rubber is equal to 0·7 only, and that of Wray's mixture = 0·8

We have still to make mention of those methods which have been frequently resorted to of late of ascertaining by means of sensible electrometers the decrease of tension in a heavily-charged cable when left to itself.

If E represents the tension of a galvanic battery in communication with the cable as observed by a sine-electrometer; Y the remaining tension in the cable after an interval of time t; K the capacity, and v the resistance of the insulator; there will be, according to the law of Ohm, after the interval t, a current of discharge $= \frac{y}{w}$, by which the tension is decreased during the time dt by dy. Hence we obtain the equation:—

$$-K \cdot dy = \frac{y}{w} dt$$

$$-\frac{dy}{y} = \frac{dt}{Kw}$$

$$C - ly = \frac{t}{Kw}$$

and since $t = o$, $y = E$,

$$\log nat. \frac{E}{y} = \frac{t}{Kw}, \text{ or } \frac{E}{y} = e^{\frac{t}{Kw}}, \text{ and } y = \frac{E}{e^{\frac{t}{Kw}}}$$

in a regular cable is $K = I. \frac{2l\pi}{l n \frac{R}{r}}$

and $W = \frac{l n \frac{R}{r}}{\lambda 2 l \pi}$

or, $KW = \frac{I}{\lambda}$

and therefore, $l n \frac{E}{y} = \frac{t\lambda}{I}$

and $\lambda = \frac{I . l n \frac{E}{y}}{t}$ ... ... (5)

and therefore $\lambda : I = \log nat. \frac{E}{y} : t.$

This method is well adapted for ascertaining the specific resistances of insulating materials and to compare the insulation of two similar cables, even when no instrument capable of exact measurement is at hand. It suffices to observe the times required for the reduction of the original tensions to a given fraction. As the proportion $\frac{E}{y}$, although unknown, is in each case the same, it is obvious from the former formula that

$$\frac{t\lambda}{y} = \frac{t_1 \lambda_1}{y}, \text{ and } \frac{\lambda}{\lambda_1} = \frac{t_1}{t}.$$

where λ and t represent specific conductivities and times occupied in both experiments.

This result is independent of any eccentricity of the wire in its insulating covering. The method is therefore well adapted for determining the specific resistance of materials; but as it is necessary to ascertain whether the wire is throughout the cable concentric with the insulator, this method cannot be exclusively used. Besides, this process requires considerable time in testing well-insulated cables. Again, another objection to its exclusive use arises from the possibility of slight faults in long cables passing unappreciated, as the loss of tension through such faults will be exceedingly small as compared with the whole charge.

We therefore prefer to determine the loss of tension not by an electrometer, but by measuring the charge a, and after the lapse of one minute the discharge b, by the galvanometer needle. We then have the loss of quantity or tension during the minute,

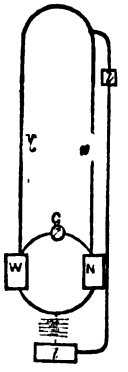
$$L = 1 - \frac{b}{a} \quad ... \quad ... \quad ... \quad (6)$$

In order to associate this formula with the system previously developed, it is only necessary to remark that $\frac{b}{a}$ is equal to $\frac{y}{E}$

The cable having been tested from the earliest stage of its manufacture (in lengths of one knot), subsequently during the joining and covering of the cable, and finally during the paying out, these tests must strictly control each other, and must consequently be recorded systematically. The chief care during the submersion of the cable should be to detect at once the slightest change in its insulation, in order that the paying out machinery may be stopped instantly. It sometimes happens, however, that a fault does not appear immediately on submersion. It is therefore necessary if a fault appears, to calculate its exact place before taking any other steps to remove it. In order to do this effectually, it is necessary to test the cable from both ends, *i. e.* from the ship and from the land station as the determination from one side gives only the maximum distance.

In paying out submarine cables we pursue the following plan of testing:—A clockwork arrangement at the land station is made to put the cable by rotation to earth, to the poles of a battery, and to insulation. On board the ship there is constantly a bridge of resistances in connection with the line. Whilst the electrician keeps the bridge in equilibrium he is enabled to ascertain alternately the resistances of insulation and continuity. The attendant of the station likewise observes the two dates, and transmits them telegraphically to the ship. If these four tests differ materially, they indicate thereby the existence of a fault, the position of which can be calculated from the dates obtained. This method of observing the conditions of the cable, although very fatiguing to the electrician employed, has been found to answer perfectly well in paying out the Indian lines. During the paying out of the Aden-Kurrachee section by Messrs. R. S. Newall and Co. we were by this means enabled to observe faults on five different occasions, which could then be removed without delay.

Our methods for determining the place of a fault are as follows:—1. When both ends of the cable are at hand, let x and y represent the respective distances from each end of the cable to the fault; l, the length of the whole cable; G, a galvanometer; and W, W_1 two graduated resistance coils. Then if W and W_1 be so adjusted that the galvanometer needle is perfectly quiet, the place of the fault is given by the formula



$$x = \frac{lw}{W \times W_1} \quad ... \quad ... \quad (7)$$

This method has already been published by Werner Siemens (Zeitschrift der Deutsch Oesterreichschen Telegraphen Vereins, 1857), having been used by us with perfect success ever since 1849.

In dealing with a single submerged line this method is no longer applicable. Let C denote the resistance of the length of the cable; x and y the resistances from each end to the fault; Z that of the fault itself; and a_1 and b_1 resistances observed from each end respectively, the further end being insulated; a and b the same while the further end is to earth. We have then by means of Ohm's law the following equations:—

1. $C = x + y$
2. $a_1 = x + Z$
3. $b_1 = y + Z$
4. $a = x + \frac{Zy}{Z+y}$
5. $b = y + \frac{Zx}{Z+x}$

By eliminating Z and y, the resistance x is found by the following expressions:—

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$$x = \frac{a_1 - b_1}{2} + \frac{C}{2} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

$$x = a \cdot \frac{c-b}{a-b}\left(1 - \sqrt{\frac{b}{a}\,\frac{c-a}{c-b}}\right) \quad \ldots \quad \ldots \quad (9)$$

or,

$$\frac{x}{y} = \sqrt{\frac{a}{b}\,\frac{c-b}{c-a}}$$

$$x = A - \sqrt{(a_1 - a)(c-a)} \quad \ldots \quad \ldots \quad (10)$$

If the cable was not perfectly well insulated before the fault under consideration appeared, the values a and b supply the means for determining an average resistance γ of the previous leakages. This resistance γ, together with the final readings of insulation a_2, b_2, gives the place of the fault as follows:—

$$x = a_1 - \gamma\sqrt{\frac{a_1 - a_2}{b_1 - b_2}} \quad \ldots \quad \ldots \quad (11)$$

In all these measurements the battery power must be so regulated as to keep the polarisation at the faulty place uniform. This is to be accomplished by determining preliminarily the place of the fault, then by regulating in the final measurement the number of cells, so as to send from each side an equally powerful current through the fault, taking care not to take the observations till the polarisation has reached its maximum. We attach considerable importance to the last formula, which alone enables us to determine the situation of new faults in old defective cables, if only its previous electrical condition is known. This knowledge is unfortunately wanting in respect of nearly all the cables that have hitherto been laid. In the instance of the Rangoon and Singapore cable we propose to furnish each station with a complete testing apparatus, and to cause daily tests to be instituted upon the cable when laid of its electrical conditions in each section. Records of these observations should be forwarded daily to the chief electrician in charge of the line, who will then have the means at his disposal to watch the rise and gradual progress of faults, and to apply the remedy at the proper moment, and with a certain knowledge of the position and magnitude of every defect.

Considering the circumstance that, owing to great care, the conductor of the Rangoon and Singapore cable is fully ten times more perfectly insulated than the best conductor hitherto submerged, we confidently expect that the result in practice will also greatly exceed that of previous experience; still, the insulating material employed remains the same, and is therefore liable to be affected by the same causes of failure.

The frequent failure of gutta-percha has given rise lately to several projects of substituting india-rubber and its compounds for the same, which, owing to the higher insulating properties and less inductive capacity of india-rubber,—and above all, owing to its greater homogeneity, and resisting power to effects of heat,—give promise of valuable results in making electric telegraphs less liable to failure. The chief difficulty consisted hitherto in working india-rubber in such a way as to obtain uniform and perfect coatings upon the conductor without injury to the material itself. We have endeavoured to remove this difficulty by constructing a covering machine, which we have brought before Section G of this Association. We do not wish however to rest upon our individual efforts for the further development of this important new branch of applied science. Great efforts have been made latterly by others eminently qualified to produce useful results. The insulating power of gutta-percha has been vastly improved, and new insulating materials are being produced.

Our object in writing this communication has been to show, that although submarine electric telegraphs have often failed, owing to insufficient experience and insufficient care bestowed upon their manufacture to guard against defects, the experience gained has not been lost; and that, in bringing the present stock of knowledge to bear upon the subject, more complete success may be insured. The British government in promoting these inquiries has stimulated and directed the individual efforts, proving that England fully appreciates the advantages of the submarine electric telegraph, and is determined to realise the same; thus contrasting favourably in this, as in many other causes of practical progress, with other nations.

Giffard's Injector for Feeding Boilers. By William Froude.

This singular and interesting instrument, in the opinion of almost all those who have had an opportunity of testing its merits, bids fair to supersede entirely the ordinary feed-pump. It is not intended here to enter into its economical merits, though these are many and obvious. But the dynamical principles involved in its action seem to need investigation, partly on account of the *primâ facie* paradoxical character of its results, and partly lest from its principles being imperfectly apprehended, and the rules for its management resting solely on an empirical basis, its results should in some instances be less successful than they ought to be.

The illustration represents a vertical section of the apparatus, which may be modified and varied in its mechanical details and the proportions of its parts. A B is a steam-pipe, leading from the boiler to the steam jet pipe C D, which is fitted at its extremity with a contracted nozzle. The aperture of this orifice is governed by the adjustable rod F, by the conical end of which it can be entirely closed at pleasure. G is a pipe connected with the supply of the feed-water, which it conveys to the small chamber I, surrounding the steam jet pipe C D. This chamber is expanded at the bottom so as to admit of the free passage of an annular jet of water which is drawn up through the pipe G by the action of the steam jet, and is tapered away to a conical outlet corresponding with the contracted orifice or nozzle of the steam jet pipe; so that the water flowing to this outlet embraces the steam jet at the point of its issue. The pipe C D is provided with a longitudinal adjustment, as shown in the illustration, by which the virtual area of the conical outlet upon the chamber I can be regulated or closed.

P is the feed-pipe leading into the boiler; it is provided with a valve at O, which permits an influx of water into the boiler, but prevents its reflux.

When the instrument is in operation the jet of steam issuing from the muzzle of the steam jet pipe CD, combines with the water which embraces it at I, and both rush together through the mouth-piece J, and valve O, into the feed-pipe P, entering the boiler;—the water thus carried in is the feed.

At the commencement of the operation, and before the motion has become established, an overflow of water takes place at the interval between the nozzle of the steam jet pipe and the contracted extremity of the mouth-piece J. This space is therefore housed in, and is provided with a waste-pipe K, through which the overflow passes into a small cistern or reservoir immediately below it, which can be emptied at pleasure.

A glazed peep-hole S, in the upper part of the housing, enables the operator to watch the result, and satisfy himself that it is such as it ought to be.

Before proceeding to discuss the *rationale* of the process, it cannot be improper to point out the apparently paradoxical character of its results. It may fairly occasion surprise to find that a jet of steam issuing from one part of a given boiler, will not only force its way violently into an aperture opened in another part of the same boiler, but will carry with it a considerable volume of water which it has taken up in its course; or, what seems still more strange, that it is capable of thus forcing its way into a boiler working under a considerably higher pressure than that from which it has issued. But the explanation appears to be sufficiently simple.

The velocity with which the particles of steam will issue from an orifice in a boiler working at a given pressure does not admit of accurate statement in very simple terms; but it will be sufficiently near the truth to say, that this velocity must be such that if we were to take an account of the momentum of the steam issuing in any given unit of time (expressing this in terms of the product of its mass or weight and its velocity), and were to compare this with the momentum of a similar jet of water or any other fluid issuing from an equal aperture under the same pressure, the momentum must be in both cases the same; for it must be the true equivalent of the force which operates through the given unit of time to create the discharge; and this, depending on the area and pressure, may be treated as being the same in both.

It may be observed in passing that a jet of steam thus issuing, if made to impinge on an aperture opening into a boiler of rather lower pressure than that from which itself has issued, would overcome the momentum of the jet which would endeavour to

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issue thence, would reverse the motion, and would itself penetrate into the boiler.

If now we could contrive simply to condense our jet of steam at the moment of its issue, as if by surface condensation, it would assume the form of a jet of water whose particles possessed exactly the same weight and the same velocity as that which they had possessed when in the shape of steam, and would possess therefore the same momentum. There is nothing in the act of condensation which can tend to modify this.

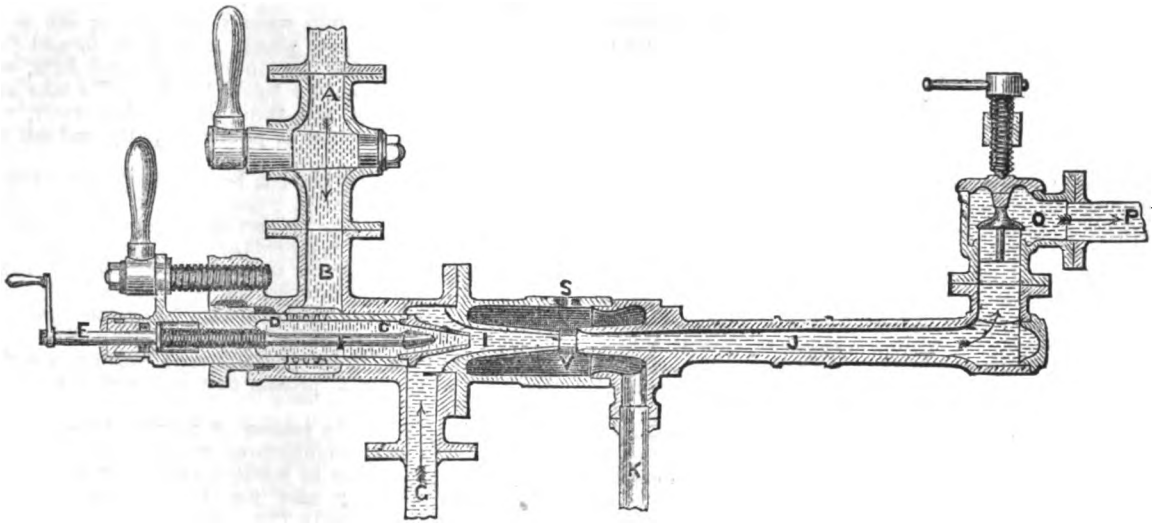
But the momentum would be embodied in a jet of very reduced diameter, and if the jet of steam possessed a sectional area of one square inch, we should find that the jet of water to which it was reduced would possess an area of only $\frac{1}{1700}$ of an inch.

Although therefore the absolute momentum of the jet would be exactly the same as it had been before condensation, its momentum per square inch would be 1700 times as great as it had previously been, and would be capable of driving back a jet of water or steam which might be attempting to issue from a boiler carrying a pressure nearly 1700 times as great as that carried by the boiler from which itself had issued.

This simple condensation would indeed be perhaps difficult to accomplish, and would be useless when accomplished, except as an illustration of a principle. But if a supply of water be allowed to flow in and mingle with the steam while it effects its condensation, as is the case in the "Injector," we accomplish an easy and very useful result. Whatever be the quantity of water which the steam takes up with it, the momentum of each unit of the compound jet thus created will remain exactly what it was; for what has been gained in its volume will have been lost in its velocity; and if only the increase of volume be limited by the condition that the sectional area of the compound jet shall be somewhat less than that of the original jet of steam had been, so as to contain the same momentum within a smaller sectional area, that jet, if allowed to impinge on a corresponding orifice leading into the feed-pipe, will be capable of freeing its way in a continuous stream into the boiler from which the steam had issued. Or if the water supplied be such as to leave the diameter of the compound jet still smaller, the jet will be capable of penetrating into a boiler having a pressure greater in the same proportion.

It would be difficult to deduce the limits governing the possible pressure of feed and volume of feed which it would be in our power to command, under the varying conditions of volume and temperature in the water supplied. But probably the practical difficulties of insuring instantaneous condensation, when the feed water is very limited in amount or very high in temperature, are such as to render the complete investigation nugatory; in point of fact, it was found difficult to manage the instruments satisfactorily in the Great Eastern when the temperature of the feed-water approached 100 deg. Fahr.

But as the only test of the correct adjustment of the instrument for successful action is for the present the purely empirical one of observing that it operates quietly and without overflow, it will be of service to point out that from the nature of the principles on which the operation depends, this apparent equilibrium may arise from two causes, one of which involves a loss of real effect. It may arise either from the fact that the steam is so fully condensed and charged with water that it is only just capable of penetrating the feed-pipe with its load, and thus the maximum effect is produced; or, on the other hand, it may arise from the fact that the supply of water is so small as to be only just sufficient to enable the penetration to take place, when of course the result will be defective: in the former case the jet will consist wholly of water; in the latter case uncondensed steam will preponderate in volume. In the intermediate condition the jet will contain an excess of penetrating power, and will therefore seize upon and carry with it a volume of air which will thus be carried into the boiler with the feed, acting injuriously in another way.



On board the Great Eastern, Mr. Appold and myself witnessed the occurrence of this very circumstance. In two separate instances we observed that air was being drawn up through the waste-pipe into the jet of feed; and the test of this was not only that light substances were drawn into it, such as threads of cotton waste or filaments of smoke, but that on filling the cistern with water so as to cover the exit of the waste-pipe, the water itself was continuously drawn up pretty rapidly, and was thus added to the feed. On our pointing out the circumstance to the fireman who had charge of the instrument, he proceeded in each case to check the suction of air, by limiting the primary supply of feed-water, thus producing an apparent improvement, while he was in truth doubly impairing the final value of the result; for he both lessened the primary supply of feed, and stopped that auxiliary supply which we had seen the instrument was ready to take up through the waste-pipe.

On the Manufacture and Application of India-rubber for Insulating Telegraph Conductors; also, the Construction of Submarine Cables. By W. Hall, Erith.

Gum caoutchouc is imported into this country in various forms. The Para rubber, which is of a superior quality, is generally sent in the shape termed bottle-rubber, and is the best of the kind adapted for manufacturing purposes. It is also sent in the shape of a tube, in order to prevent waste in the process of cutting it into strips or threads.

Prof. Faraday says that no appearance of texture can be observed in the pure transparent caoutchouc; it resembles exactly a piece of clear strong jelly. All the phenomena dependent upon its elasticity which are known to belong to common caoutchouc are well exhibited by it. When very much extended, it assumes a beautiful pearly or fibrous appearance; and when doubled several times, until further extension in the same direction is difficult, it is found to possess great strength. Its specific gravity is 0·925, and it is a non-conductor of electricity. The pure caoutchouc has a very adhesive surface; its fresh-cut surfaces pressed together also adhere with a force equal to that of any other part of the piece.*

The first process employed is to cleanse it by boiling, &c., and

* See 'Quarterly Journal of Science and the Arts,' R. I. G. B., vol. xxi., No. 21.

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then cut the top and bottom of the bottle, which leaves it in a cylindrical form, suitable for cutting it into strips or any other form as may be required.

The machine for cutting the rubber into strips is composed of a circular knife, arranged so as to cut it of one uniform thickness. In front of the circular knife there is a revolving spindle, having a screw cut upon and working through a nut of the same pitch at one end; also a pulley or drum on the other end of the spindle, so as to cause the knife and spindle to revolve at different speeds when the machine is in operation. On the spindle is fixed a soft wooden roller, from three to four inches in diameter, the surface of the roller being in contact with the circular knife, when the latter is in motion. Upon this roller is stretched the bottle or cylinder of rubber, in a moist and warm elastic state. Motion being given to the machine, cold water is allowed to drip on the knife during the process of cutting the rubber into strips, so as to prevent the pieces from adhering to each other, and the strips are then cut into one uniform width by a small circular cutting machine adapted for that purpose. The rubber thus prepared is then submitted to a peculiar mode of treatment, preparatory to being used for covering telegraph conductors. It would be difficult to describe all the particulars as regards the mode of preparing the rubber. I may state however, that it is essential to use the rubber at various temperatures—say from 100 deg. to 200 deg. Fahr., as may be required for the purpose for which it is ultimately intended.

India-rubber as imported generally includes mixed impurities of different kinds, which are got rid of by tearing it up into shreds in a stream of water, it is then transferred to a machine called a masticator, where it is severely pinched and kneaded till it forms a kind of mass, which may be compressed into blocks, cut into sheets, strips, or threads, or rolled into layers of any thickness, as may be required.

The masticating machine consists of a hollow cylinder with an opening at the top, so as to receive the cuttings and scraps of rubber. A shaft passes through the cylinder; this part of the shaft is grooved, so as to form projections about half an inch square along the whole of its length within the cylinder. The ends of this shaft are turned to a suitable size to pass through the ends of the cylinder and to run in bearings upon the frame. The india-rubber should be cut into small pieces and well cleansed and dried, and then passed through warm rollers. This operation causes many of the pieces to unite and form sheets of various lengths, after which the rubber is put into the cylinder and the opening closed. Motion being given to the shaft, it is communicated to the india-rubber, and in the course of an hour, more or less according to the speed of the shaft and the quantity of rubber employed, the combined action of heat and friction occasioned by the motion and pressure of the india-rubber has the effect of uniting it into one compact mass or roll of the length of the interior of the cylinder. Should any granular particles be seen, the operation must be repeated until they disappear. It is a fact worthy of note, that this mode of treating rubber was the origin of the india-rubber manufacture; and the process has been in use about thirty-five or forty years. For the formation of this mass into square or round blocks a heavy pressure is required. The blocks may be 6 feet long, 12 or 15 inches wide, and 10 or 12 inches thick.

The machine for cutting the blocks into sheets consists of a cast-iron box of sufficient length to receive them. The box has a moveable bottom, which may be raised or depressed by screws. There is a screw running the whole length of the frame, so fitted to it that each end is made to pass through a projecting piece of metal attached to the sides of the box; and, by turning this screw, the box is made to move backwards or forwards, as may be required. At one end of the machine, and at right angles with it, a straight knife is fitted to an eccentric motion: when the machine is in operation the screws are brought down, followed by the moveable bottom, and the block of rubber, having its sides soaped, is put into the box and pressed down upon it, the screws are then turned round, so as to raise the block of rubber a little above the plates on the upper edge of the box, in order to have the sheets cut of any required thickness. Motion being given to the machine, the knife, which is kept wet by water dripping on it, is also set in motion, and at the same time power is given to the long screw, which causes the box with the rubber to advance and to come in contact with the knife; and thus a sheet of rubber is cut from the block. When one sheet is cut, the box is brought to its original position by reversing the motion of the long screw, after which it is only necessary to raise the rubber to the required height by screwing up the moveable bottom of the box; and so long as any rubber remains uncut this operation has to be repeated. These sheets can be joined together when they are required for tubes, such forms being suitable for cutting the rubber into strips by the same machine, and by the process just described.

I have been engaged in experiments upon gutta-percha since 1844. This substance was introduced into this country by Dr. Montgomery, through the Society of Arts, in 1843. Dr. Montgomery's mode of treating it was as follows:—"The gutta-percha when dipped into water nearly boiling can be readily united, and becomes quite plastic, so as to be formed (before it cools to 130 deg. or 140 deg.) into any required form, which it retains at any temperature below 110 deg. We take as much of it as is necessary, and throw it into hot water, when it soon softens and becomes as plastic as putty, and can then be moulded as required."

This substance, however, has been extensively used for covering telegraph conductors in consequence of its easy application and moderate insulating properties. I may state without fear of contradiction, that india-rubber is by far a better insulator, and gives better results as to its electrical qualities than gutta-percha. I shall, therefore, confine my remarks to the mode of applying india-rubber for insulating telegraph conductors, in preference to gutta-percha or any of its compounds.

The method used in covering telegraph conductors with gutta-percha is so simple a process that explanation here is unnecessary.

Having explained the process of treating india-rubber, both in its natural and manufactured state, I will describe briefly its mode of application to insulating telegraph conductors prior to gutta-percha being used for that purpose. The method adopted was as follows:—The wire being first covered with cotton, was then varnished over with shellac and covered with one thin strip of manufactured rubber. Preparatory to using the latter, one side of the strip was coated with dissolved india-rubber, or any of the known solvents, so as to render the rubber homogeneous and waterproof; and I believe, that if these cores have not generally been brought into use for telegraphic communication, it has been owing to the circumstance that they have been imperfectly constructed, and therefore not suitable for that particular purpose. In the meantime, gutta-percha has been so used; and it is a well-authenticated fact, that the greater part of the cables made from it have failed.

Having had twenty-eight years' experience in the manufacture and application of india-rubber and gutta-percha to the various purposes for which they are used, I felt assured that some great improvement might be made in insulating conductors with the before-mentioned gum, and I commenced first by covering the wire with the best cotton fibre, and then covered the cotton with strips of pure rubber cut from the bottle or any other form as imported. These strips were laid on spirally and with overlap. I then wound round, in an extended form outside the spiral lappings of rubber, a thread of vulcanised india-rubber covered with cotton or otherwise, and finally coated the latter with yarn saturated with best Stockholm tar. The whole of these operations were performed at one and the same time by a machine especially adapted for that purpose. In addition to the former process, I then submitted the core to a dry temperature of 120 deg. or 130 deg., in order to render the lappings of rubber homogeneous and waterproof. I should remark that it requires great care and practical experience in reference to the temperature which it is necessary to employ, so as to insure a perfect core without destroying the properties of the india-rubber. These cores, if properly constructed, will withstand nearly any amount of hydraulic pressure, thus rendering them particularly adapted for submarine cables or any other telegraphic purposes.

Hitherto telegraphic conductors have been insulated with gutta-percha; but nevertheless, it has been found that when it is immersed in the sea, laid in the earth, or subjected to atmospheric influence, in fact to any change of temperature, its electrical condition will be materially effected, so that in a short time it is partially destroyed, rendering it nearly useless for submarine cables.

It is an established fact, that when gutta-percha was first introduced into this country, about sixteen or seventeen years since, it was of a superior quality, but at the present time it is

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found to be of a very inferior kind, and it is obvious that this is one cause of its failure for telegraphic purposes. In the manufacture and application of gutta-percha for telegraphic cores there are many difficulties to overcome, viz., to cleanse it from all impurities, to keep it free from moisture and the accumulation of air cells during the process of its application to the conducting wire or wires, also the uncertainty of the conducting wire being in the centre of the core. I am of opinion also that gutta-percha has not sufficient affinity when incorporated with india-rubber and shellac, that would improve its insulating properties, so as to render it a perfect insulating medium, which is so essential for submarine cables. I think, therefore, that nearly all the failures in telegraphic cables, &c. are attributable to the inferior quality of gutta-percha, as well as the attempt to improve it by the introduction of foreign substances, which no doubt make it still worse. This is apparent to anyone who has taken the pains to investigate the causes of the many failures that have taken place within the last few years.

I have before stated that india-rubber was used for telegraphic purposes before gutta-percha. The cause of its failure in the first instance was in consequence of the parties not being thoroughly conversant with its manufacture and method of application; the result was that the properties of the india-rubber were destroyed by the artificial means used in order to render the rubber homogeneous and waterproof.

I have seen wires which were covered with india-rubber nearly upon the same principle, namely, by immersing the rubber cores in hot water, in order to render the capping of rubber homogeneous, and, as a necessary consequence, the caoutchouc becomes black, and has a very strong tendency to decompose; in fact, the solvent used does not evaporate when the rubber is submitted to such a mode of treatment. Moreover, the copper wire conducting heat much more rapidly than the rubber, tends to induce decomposition; still the insulation may be perfect, although I am of opinion that cores constructed in the manner just described can only last for a short time.

There are some persons who contend that neither cotton nor fibre should be used in covering the conducting wire previous to coating it with india-rubber or gutta-percha; and there are others who think it of practical utility. I must confess that I belong to the latter class. The reasons I adduce are—that no conducting wire should come in direct contact with the insulating agent, whether it be gutta-percha, india-rubber, or any other agent. Now, if cotton fibre or raw silk is used, no chemical action is likely to take place between the conducting wire and the insulating medium; on the contrary, it might possibly destroy its insulating properties. Again, the use of cotton fibres gives pliability to a core, and prevents the conducting wires from protruding through the insulating medium, in the event of the core becoming twisted or bent during the process of its manufacture into a cable, or from its becoming coiled: it also obviates the danger of a similar occurrence when the cable is being run out from the vessel at sea. If a gutta-percha, or any hard compound core, is bent backwards and forwards, the conducting wire does not recover its original condition of adhesion to the gutta-percha as hitherto made. I am of opinion, therefore, that it is of the greatest importance to closely cover the wire with the best quality of cotton fibre, or raw silk, previous to coating it with india-rubber, &c., in order to insure a durable and perfect insulating medium for submarine cables or subterranean conductors.

It has hitherto been the custom to make all submarine cables with an outer coating of wire rope; but it is not my intention in the present paper to offer more than a few words in reference to this part of the subject, because it has been described so often by our eminent engineers, some of whom seem to be of opinion that the wire ropes are not in all cases suitable for submarine cables, from the fact that their specific gravities are very high, and their spiral form causes them to elongate to a very great extent when a heavy strain is put upon them in being paid out from the ship. I think, therefore, that all spirally covered cables have a strong tendency to destroy the insulating medium, whatever the insulating agent may be made of. In connection with the former remarks an article appeared in the 'Times' on the 9th April, 1860, as follows:

"There is not a single engineer of eminence who does not condemn the principle of laying on the outside wires spirally instead of longitudinally in a line with a strain they have to resist. Why the old arrangement is persisted in at the present day it is difficult to imagine, unless it is due to the fact that most of the wire rope manufacturers have their machines constructed for laying on the wire spirally, and do not care to make others which will render the completion of their work slower, more difficult, and less profitable. Four years ago, when the plan of construction of the Atlantic Cable was resolved on, we most strongly deprecated this arrangement, and the event has so clearly justified what we then pointed out would be the consequence, that we may be excused for quoting the opinion on the present occasion: 'Whenever a cable is constructed with spiral wires round a soft core, any severe strain in paying it out must, by stretching the outside wires, either attenuate or break the insulation of the copper conductor. This is a simple fact which those least conversant with mechanics can easily understand. We do not mean to say that the Atlantic cable cannot succeed, but the chances are much against it, and it is certain that before it has been down twelve months it will, like most others similarly constructed, be perfectly useless. If it does answer even temporarily, it will not be due to the plan on which it is made, but in spite of it.'" Moreover, Mr. Gladstone also stated in Parliament, on the 8th June, that, "The experience of the last twelve months had greatly increased the doubts which were entertained with reference to the difficulty of laying deep-sea cables, and the instances of failure had been so numerous as to be all but universal, and there was but one deep-sea cable, he believed, at present in operation." These are plain facts, and I think it quite evident that some great improvement is required, taking into consideration the enormous amount of capital which has been and is still being sacrificed.

It appears to me that it is of the greatest importance that the external covering for the conductor of a submarine cable should be made of the best material, and not less than a quarter of an inch thick when made with hemp and steel wire, and the latter to be as near as possible to the external surface, so as to preserve the core from injury, also to obtain the utmost amount of longitudinal strength. The method I adopt is by inserting longitudinal steel wires (without any twist) in combination with the hemp or wire covering, formed upon a double plaiting or braiding machine, on the hollow tube principle, whereby the longitudinal wires may be introduced, so as to give strength and lightness, at the same time be free from any twists or liability to kink. By this mode of construction different lengths of cable can be joined together with great facility, and can be made of a specific gravity of 1·25 and upwards.

To describe more fully particulars in reference to cables, it will be essential to explain a few calculations based on the following data:—Let $s = 1$ the specific gravity of sea-water; C, the specific gravity of a cable compared with the former, and T its tensile strength in tons; W, the weight in tons of one mile of cable in air; x, the weight of one mile of the latter in sea-water; F, the number of fathoms in a mile; and L, the length in fathoms that would break with its own weight when suspended in sea-water. From these data I obtain the equations for calculating the weight (x) of one mile of cable in sea-water, also L, the length in fathoms.

Now $\frac{S}{C}$ = the loss of weight, and $\left(S - \frac{S}{C}\right)W = x$, the weight of one mile of the cable in water. Therefore, as

$$\left(S - \frac{S}{C}\right)W : F :: T : \frac{T \times F}{\left(S - \frac{S}{C}\right)W} = L, \text{ the length in fathoms.}$$

As an example let us take the specimen produced (No. 3 in table), which is made with eight steel wires No. 15 gauge: weight per mile, 1 ton; tensile strength, 2 tons; specific gravity, 1·56.

Now from the equation $\left(S - \frac{S}{C}\right)W = \left(1 - \frac{1}{1{\cdot}56}\right)1 = {\cdot}3525$ ton, the weight of one mile in water; and from the latter equation we obtain L, which is

$$= \frac{F \times T}{\left(S - \frac{S}{C}\right)W} = \frac{880 \times 2}{\left(1 - \frac{1}{1{\cdot}56}\right)1} = 4993 \text{ fathoms,}$$

as before stated.

Again, $\frac{{\cdot}3525}{880} = {\cdot}0004$ ton, the weight of 1 fathom; therefore the minimum tension at 2000 fathoms (this being considered the average depth of the sea) is $2000 \times {\cdot}0004 = {\cdot}8$ ton, allowing

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three-fifths of its tensile strength in the event of the cable being strained by paying it out from the vessel. Now by taking the Atlantic cable (No. 6 in the table) as another example, and by calculating from these equations according to the following authentic data, namely the specific gravity of 4·00, and weighing one ton per mile; also the tensile strength somewhat less than 3 tons; we find the length (L) would be 3520 fathoms, and the minimum tension at 2000 fathoms 1·704 ton, being about $\frac{17}{30}$ or more than half its tensile strength.

The merits of the cores and cables I have described (with many others not here mentioned), will be examined and fully reported upon by eminent electricians and engineers appointed by government for that special purpose.

I may state that Prof. Airy, Mr. Longridge, and J. Bodie, R.N., and master of H.M.S. Agamemnon, have given some valuable tables in reference to the submerging of telegraphic cables. Those by the two first-named gentlemen are to be found in the Journal of the Institution of Civil Engineers;* and the latter in the 'Mechanic's Magazine,' Oct. 1858.

Having already described the method of constructing deep-sea cables, I will now give the cost in reference to the specimens produced. One example cost about £45 per mile; when made into a cable, about £120. Another, much lighter, about £115 per mile: weight 14 cwt., tensile strength 2·09 tons, specific gravity 1·9; the length that would break with its own weight when suspended in sea-water is 5522 fathoms; the minimum tension at 2000 fathoms is 0·756 ton.

The following experiments show the relative weights and tensile strength of cables varying in construction and specific gravity.

Table of Experiments.

	The value of C.	The value of W.	The value of x, from formula, $x=\left(8-\frac{8}{C}\right)W$.	The value of T.	Calculated length that would break with its own weight when suspended in sea-water, from formula, $L=\frac{F\times T}{\left(8-\frac{8}{C}\right)W}$	Braided external covering.	Insulation.	Diameter of cable.	Remarks.
		Tons.	Tons.	Tons.	Fathoms.				
1	1·25	0·834	·1668	1·3062	6891	Russian hemp	India-rubber	1 in.	24 longitudinal strands of hemp.
2	1·5	0·8348	·2782	1·515	4792	Hemp & steel	,,	,,	20 longitudinal strands of hemp, and 4 steel wires, No. 14 guage.
3	1·56	1·	·3525	2·	4993	,,	,,	1¼	20 longitudinal strands of hemp, and 8 steel wires, No. 15 guage.
4	1·5	0·75	.25	1·4	4928	,,	,,	1	20 longitudinal strands of hemp, and 8 steel wires, No. 16 guage.
5	1·9	0·70	·3315	2·09	5522	,,	,,	⅞	20 longitudinal strands of hemp, and 8 steel wires, No. 14 guage.
6	4·	1·	·75	3·	3520	Iron wire	Gutta-percha	⅝	Spirally covered cable, with best charcoal wire, No. 22 guage.

On the Relations between the Arcs of Hyperconic Sections and Elliptic Integrals. By Dr. Booth.

My object in this short paper is to call the attention of mathematicians to a class of curves which I have named hyperconic sections. They are the curves of double curvature generated by the intersection of a sphere or a paraboloid of revolution with a concentric cone. The curves formed by the intersection of a spherical surface with a concentric cone have been known for several years under the name of spherical conics, and have formed the subject of the voluminous and elegant researches of MM. Chasles, Catalan, Gudermann, and a host of other continental geometers, and more recently of our Oxford, Cambridge, and Dublin mathematicians, Salmon, Cayley, Graves, Roberts, and others. But I am not aware that the analogous curves, those of double curvature formed by the symmetrical intersections of a paraboloid of revolution with a concentric cone, or as the centre of this cone is at an infinite distance—with a cylinder having a common axis with the paraboloid—have ever been investigated; yet these curves have a peculiar interest, because their arcs are the geometrical types of elliptic integrals of the third order and *logarithmic* form. They are eminently deserving of investigation from the curious analogies they present to spherical conics and plane conic sections.

I will make a few preliminary observations before I proceed further with the statement of these remarkable analogies. It is known, I presume to every mathematician, that the length of an arc of a plane ellipse may be expressed by the integral $s=a\int d\phi\sqrt{1-c^2\sin^2\phi}$, and as this particular form is one of a more general class, which may be written

$$s=a\int\frac{d\phi}{(1-\rho\sin^2\phi)\sqrt{1-c^2\sin^2\phi}}$$

this latter and all its subordinate cases obtained the name of elliptic integrals.

It is now more than twenty years since MM. Catalan and Gudermann showed in the journals of Lionville and Crelle that when ρ is greater than c^2, but less than unity, these formulæ represent the arcs of spherical ellipses; and as by Fagnani's theorem a right line may be found which shall be the difference of two elliptic arcs measured from the vertices of the major and minor axes, so in the spherical ellipse an arc of a great circle may be found which shall be the difference between two arcs of the spherical ellipse measured from the extremities of the principal arcs.

So far the continental geometers pushed their researches, but no analogous representative curves were found for the elliptic integral of the first order, or for the logarithmic form of the third order.

In a treatise which I published nearly ten years ago, "On the theory of elliptic integrals applied to the investigation of the motion of a body round a fixed point," I was the first, I believe, to show that if we take that particular spherical conic section generated by the intersection of a cone whose vertex is at the centre, and whose base is a parabola the plane of which touches the sphere at its focus, this particular spherical conic may be rectified by an elliptic integral of the first order, or we shall have

$$s=a\int\frac{d\phi}{\sqrt{1-c^2\sin^2\phi}}$$

In fact it is shown in all elementary treatises on this subject that this integral of the first order may be reduced to an integral of the third order whose parameter $\rho=c$.

Following up this investigation I showed in a memoir printed in the Philosophical Transactions for 1852, that if we take a paraboloid of revolution and an elliptic cylinder having the same axis, the intersection of these surfaces will be a closed curve like an ellipse,—I have called it the logarithmic ellipse. Now this curve possesses this curious but analogous property, that its arc may be expressed by an elliptic integral of the third order and logarithmic form whose parameter is greater than c^2 but less than unity.

As in the case of the plane ellipse the difference of two arcs may be expressed by a right line, and in the spherical the difference of two arcs may be represented by an arc of a great circle,

* See *C. E. & A. Journal*, vol. xxi. (1858) pp. 180, 202.

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so in the case of the logarithmic ellipse, the difference of two arcs may be expressed by an arc of a parabola, one of the principal sections of the paraboloid; and as the arc of a parabola can only be rectified by logarithms, hence the propriety of the term logarithmic form.

In the next place when the parameter is greater than unity and consequently greater than the modulus squared c^2, we have to find the curve. Retaining the paraboloid of revolution as before, let the cylinder stand on an hyperbola instead of an ellipse, the section of the paraboloid cut by this hyperbolic cylinder may be called the logarithmic hyperbola, and the vertical planes which stand on the asymptots of the hyperbolic base will cut the paraboloid in two plane sections, namely, in parabolas, which parabolas will manifestly be asymptots to the infinite branches of the logarithmic hyperbola.

It is well known that the difference between the infinite branch of a common hyperbola and its infinite asymptot is a finite quantity; so it may easily be shown that the difference between the infinite branch of the logarithmic hyperbola and the infinite branch of its asymptotic parabola is also a finite quantity.

It is worthy of notice that when the parameter $\rho = +\infty$ the elliptic integral represents a circle, when $\rho = -\infty$, it represents a parabola, thus the circle and parabola are the two extreme limiting cases of elliptic functions. Hence we derive this general and I may add important theorem: That elliptic integrals of every order, the parameter taking any value whatever between positive and negative infinity, represent those curves of double curvature which are the intersections of surfaces of the second order.

These surfaces divide themselves into two classes, of which the sphere and paraboloid of revolution are the respective types: from the one arise the circular functions, from the other the logarithmic and exponential. The circular integral of the third order is derived from the sphere, while the logarithmic integral of the same order has its origin in the paraboloid.

In fact the theory of elliptic functions may be defined as the trigonometry of the arcs of hyperconic sections, of which the two extreme or limiting cases are the trigonometry of the circle and the trigonometry of the parabola, or the relation between the arcs of the principal plane sections of a sphere and a paraboloid; hence every general theorem in elliptic functions contains, according to the limitation we make or the conditions we introduce, either a theorem in circular or parabolic triognometry.

I have shown also on another occasion how any theorem whatever being given in circular trigonometry, we may obtain the corresponding theorem in parabolic trigonometry by the well known and simple imaginary transformation $\sin\theta = \sqrt{-1}\tan\phi$; and this is the very transformation by which we are enabled to pass from the circular form to the logarithmic form of the third order. And as the sphere and paraboloid are surfaces irreducible one to the other by any finite variation or rational transformation of the constants in their equations, we hence see the reason why no refinement of analytical artifice could enable the most accomplished geometers to pass from one form of function to the other. When the intersecting surfaces of the second order are neither concentric nor symmetrically placed, the rectification of the curve of intersection may be reduced to the integration of an expression of this form, which may be called a hyperelliptic integral:

$$s = a\int dx \sqrt{\frac{ax^4+\beta x^3+\gamma x^2+\delta x+\epsilon}{ax^4+bx^3+cx^2+dx+e}}$$

in which x rises to the 8th power.

When the surfaces are symmetrically placed and have a common plane of contact, the expression may be reduced to

$$s = a\int dx \sqrt{\frac{ax^3+\beta x^2+\gamma x+\delta}{ax^3+bx^2+cx+d}}$$

and when the surfaces are concentric and symmetrically placed, this expression may be still further reduced to

$$s = a\int dx \sqrt{\frac{ax^2+\beta x+\gamma}{ax^2+bx+c}}$$

which is the general form for elliptic integrals.

We may hence perceive, therefore, that the solution of the general problem to determine the length of the curve in which two surfaces of the second order intersect, investigated under its more general form, far transcends the present powers of analysis. It is only when one of the surfaces becomes a plane, or when they are concentric and similarly placed, that the problem under these restricted conditions admits in our present state of knowledge of a complete solution.

In the logarithmic hyperconic sections we may develope properties analogous to those found in the spherical and plane sections, if we substitute parabolic arcs for arcs of great circles in the one and for right lines in the other. Hence follow a few of those theorems. From any point on a parabolic section of a paraboloid let two parabolas be drawn touching the logarithmic ellipse or the logarithmic hyperbola; the parabolic arcs joining the points of contact will all pass through one point on the surface of the paraboloid. If a hexagon whose sides are arcs of parabolas, be circumscribed to a logarithmic ellipse, the parabolic arcs joining the opposite vertices of the circumscribed hexagon will pass through a fixed point on the surface of the paraboloid. And reciprocally, if a hexagon whose sides are parobolic arcs be inscribed in a logarithmic ellipse or logarithmic hyperbola, the opposite parabolic arcs will meet two by two on a parabola. If through the centre of a logarithmic ellipse or logarithmic hyperbola two parabolic arcs be drawn at right angles to each other, meeting the curve in two points, and parabolic arcs be drawn touching the curve in these points, they will meet on another logarithmic ellipse or logarithmic hyperbola.

I might supply many other theorems, but these will suffice,—there would be little difficulty in extending the list; in fact, nearly all the projective properties of right lines and conic sections on a plane may be transformed into analogous properties of great circles and spherical conic sections on the surface of a sphere, or of parabolic arcs and logarithmic sections on the surface of a paraboloid.

It is somewhat curious, that nearly the whole of our mathematical investigations as hitherto developed, such as trigonometry plane and spherical, parabolic trigonometry, the theory of logarithms as also that of exponentials, and the theory of elliptic integrals of the three orders, may all be considered as solutions of particular instances of the one general problem—to express the length of an arc the symmetrical intersection of surfaces of the second order. As I have said on a former occasion, this view will suggest the reflection, how very contracted is the portion of that vast region, the integral calculus, which has hitherto been cultivated or even explored. When we find that our highest and most abstruse functions, not only circular functions and logarithms, but also elliptic integrals of the three orders, with our most refined analytical artifices, in the hands of even the most accomplished mathematicians, are exhausted—used up, so to speak, in the solution of a problem apparently so simple as to find the length of an arc of the curve of symmetrical intersection of two surfaces of the second order, who shall exhibit and tabulate and reduce those higher functions which represent the unsymmetrical sections of surfaces of the second order, or generally those curves of double curvature in which surfaces of the third or higher orders intersect? Considerations such as these but add fresh evidence to the truth, how small even in Mathematics, that most triumphant victory of man's reason, is the proportion which the known bears to the unknown.

On a New Method of Insulating Submarine Telegraph Conductors with India-rubber or its Compounds. By WERNER and C. W. SIEMENS.

IN Section A we have laid before the Association a paper on the methods we employ in testing submarine cables electrically, and on the causes of their frequent failures.* We have shown there that gutta-percha, which is the material now universally applied for insulating electric conductors, is liable to be acted upon destructively by the electric current in places where the insulating covering contains cavities or eccentric places, which it is extremely difficult, if at all possible, wholly to avoid. We have shown moreover that the insulating property of gutta-percha is vastly inferior to that of india rubber and its compounds, and that its inductive capacity (or retarding influence upon the electric current) is much greater. India-rubber and its compounds are, moreover, not liable to be softened by summer heat, and would therefore be exempt from this and other sources of frequent failure in gutta-percha. India-rubber has been employed for the purpose of insulating telegraphic conductors more than twenty years ago, when it was employed by Jacobi, of St. Petersburgh, for underground telegraphic lines. In 1846, Wer-

* See Journal *ante*, page 264.

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ner Siemens employed it, previous to his application of gutta-percha to the same purpose. About the same time india-rubber was put to the same use in this country, and, it is said, remains still in good working condition in Portsmouth Harbour.

There is nothing new then in our proposal to substitute india-rubber and its compounds for gutta-percha in insulating submarine or other telegraphic conductors. Our proposal has reference to a new method of effecting the covering.

The general method hitherto adopted consists in cutting the rubber into strips, and in winding these strips spirally upon the wire to be insulated,—a tedious and expensive operation, which has to be repeated several times to afford any security that the water is entirely excluded from the wire. The insulation of the wire depends in fact upon the perfect joint formed throughout between the strips; for it is evident that where the strips overlap a spiral channel is formed, which, if in any one place penetrated, will allow the water to spread till it may chance to find a transverse passage into the spiral channels of the lower coating, and so forth, until it reaches the wire. Formerly the layers of india-rubber simply touched one another, and could readily be displaced; but lately a process of soldering the spiral layers has been introduced by Messrs. Silver and Co., which greatly increases the security of the coating, although it does not remove the objections to the spiral channel which must always be formed in lapping. This process of soldering consists in exposing the covered wire to boiling water for about half an hour, when a most perfect cohesion between adjoining surfaces is found to be established.

The india-rubber so treated adheres to the fingers, or feels sticky; it also loses part of its elasticity and strength. It may therefore be inferred that the heat produces some chemical alteration in the india-rubber, changing the gum into an oil.

It has been observed that india-rubber so heated has gradually changed bodily into a viscid liquid where it is in contact with the metal conductor, so as to render it unsafe to be used.

The method of covering which we propose to substitute for the above combines the advantages of comparative cheapness and certainty of result with that of rendering the application of heat unnecessary. We base our operation on the well-known adhering property of india-rubber when two fresh-cut surfaces are joined under considerable pressure.

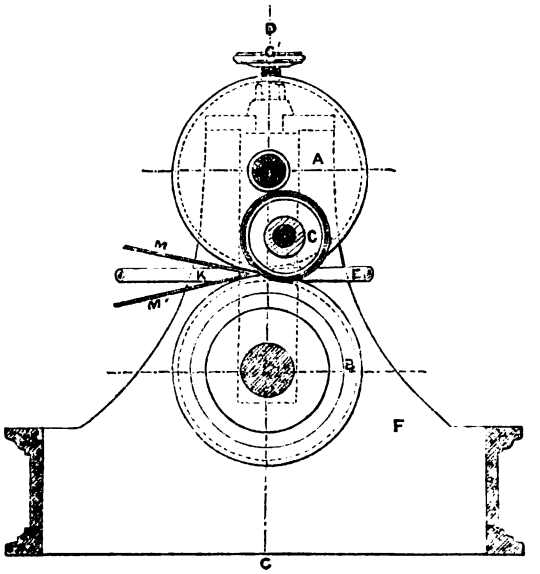
The mechanical problem consisted in the construction of a machine which would draw the india-rubber tight upon the wire, so as completely to exclude atmospheric air; to cut the same in the proper inclination; and in joining the fresh cut edges at the same instant, under such pressure as to make the joint perfect.

The machine finally arranged for this purpose consists of two grooved rollers, A and B, and two cutting or shearing rollers, C C, all of which are of hardened steel. On each side of the groove of the rollers A and B is a cylindrical part of a breadth, equal, or nearly so, to the thickness of the intended coating to be applied; but the cylindrical sides must be slightly rounded off towards the grooves and sharp at the sides.

The cutting rollers are so placed that in turning round their shearing edge crosses the edges of the grooved rollers a little before the central line of the machine, or at a point where the distance between the edges of the grooved rollers is about equal to half the thickness of the strip of india-rubber used. The axis of the cutting rollers is slightly inclined towards the axis of the grooved rollers, so that being pressed against the same by means of set screws, they only touch hard at the shearing point.

The wire to be covered and the two strips of india-rubber are conducted into the machine by suitable guides. The two strips, in closing upon the wire, are drawn tight over it by the inner edges of the grooved rollers, and the double strips caught between the closing cylindrical portions of the grooved rollers is reduced to one-fourth the original thickness (forcing the material outward from the middle), when the cutting rollers suddenly intersect, severing the superfluous breadth of strips, and at the same time preventing further escape of the material towards the sides. As the edges of the grooved rollers continue to close upon one another the material remaining between them can only escape inwardly, by which means the fresh cut edges are brought the one upon the other, under a heavy rolling pressure, from which they glide away towards the groove, and in so doing form a complete and permanent join.

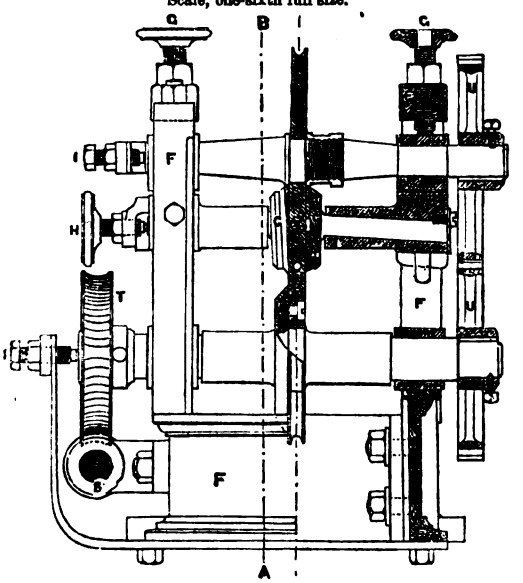
In order to effect several successive coatings a train of machines is provided, and so placed that the wire to be coated passes in a straight line through them all, receiving in each successive machine an additional coating, with the longitudinal seam at right angles to those of the previous and succeeding coatings. This is effected by the different angular positions in which the machines are placed. The last machine in the train is supplied with strips of india-rubber covered cloth, or felt, which is also capable of



SECTION ON LINE AB.

A, B. Grooved steel rollers.
C, C. Cutting ditto placed eccentrically.
F. Frame.
S. Endless screw to give motion to machine.
T. Screw wheel.
U, U. Spur wheels of transmission.
G, G. Screws to adjust vertical pressure.
H. Adjusting screw of lateral pressure.
I, I. Elastic adjusting screws.
K. Wire to be covered.
E, Wire covered.
M, M'. Strips of india-rubber.

Scale, one-sixth full size.



HALF-SECTION ON LINE CD.

being joined by compression of the fresh-cut edges, and is extremely useful in adding firmness and protection to the insulated conductor. This machine is also applicable, with certain modifications of detail, for covering wire with the interesting compound of india-rubber, shellac, and pounded flint, which is known by the name of "Wray's mixture," and possesses in common with india-rubber very remarkable insulating properties.

The machine is also applicable, with great apparent advantage, for the manufacture of india-rubber tubes, and for several other similar purposes.

Wire covered by this process has been subjected to severe electrical tests which have proved highly satisfactory. A single covering suffices to insulate the wire, but it is always preferable to apply a succession of comparatively thin coatings. Half a mile of wire, with four successive coatings, has been tested in Camden Town, by the government Commission of Inquiry into

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telegraphic matters, whose report will shortly be published. Two complete trains of machines are now in course of preparation for the two principal manufacturing firms of india-rubber and Wray's mixture-coated wire; and we hope that, through their application, the cause of submarine and subterranean electric telegraphs will be advanced a step.

On the Geography of the North Atlantic Telegraph.

By T. P. SHAFFNER.

It is not my purpose to discuss the commercial advantages of an Atlantic telegraph. The cost of the line, the expense of maintaining it when made, the profits on the investment, the advantages of one route compared with another, are questions that cannot be entertained here; but the countries to be traversed by the North Atlantic telegraph can be considered by this section of the Association with propriety. I propose to discuss the geography of the proposed telegraphic route, so far as pertains to the Faroe Isles, Iceland, Greenland and Labrador.

Before entering upon the subject proper, it is due to the friends of the enterprise to make a few remarks relative to the history of ocean telegraphy. The Northern telegraph is not a new idea, freshly conceived and advanced for the consideration of men, nor has it been brought into existence by the failure of the late Atlantic telegraph, nor do the friends of the northern route claim any advantages from the experience so dearly purchased by the shareholders of the Atlantic Company. That enterprise commenced its career in 1856. It commanded the confidence and the money of the British public. The liberality bestowed upon it by the British and American governments, and the immense investment of money and labour in it, added lustre to the nations. It is to be lamented that the most triumphant success was not achieved. The failure of that gigantic enterprise is not alone regretted by those who placed their money in it as a speculation, but by all the civilised world. In 1854, I obtained the Danish concession to construct the telegraph from Europe to America, over the Faroe Isles, Iceland, and Greenland. The line will traverse Labrador and Canada to Quebec. The success of this enterprise was not promotive of the interest of some New Yorkers who were the owners of the monopoly of telegraphy in Newfoundland, and it was by their efforts that the Atlantic Company was organised for the line from Ireland to Newfoundland in 1856. I mention these circumstances, that the public may know that the Northern enterprise is not of recent origin, but that it is older than the Atlantic Company. If there be a sin for the establishment of rivalry in ocean telegraphy, it does not belong to the promoters of the Greenland route. It is necessary for me to be understood, however, as not being an opponent of other lines across the ocean. I am in favour of as many as can be laid, confident that the Northern route, with its means of celerity of transmission, will have all the business it can do, and that other lines will have all that they can do.

It is not now my purpose to discuss the relative merits of the ocean telegraphs, except in such matters as pertain to physics common to submarine telegraphy.

The route of the telegraph, as marked upon the map, is from Scotland *viâ* Faroe Isles, Iceland, Greenland, and Labrador, to Quebec, there connecting with other lines to different parts of America.

The sea sections of the proposed telegraphic route are as well known to all nautical geographers as to myself, excepting perhaps the places sounded by the telegraphic expedition last autumn between Labrador and Greenland and between Greenland and Iceland. The bottoms of those seas were found to be deep mud, and a cable once laid thereon will lie undisturbed for all time. Neither the heaving of the seas nor the spire-like iceberg will disturb the fiery cable reposing beneath their white-crested waves. Icebergs float; and there will be no part of the sea in which the cable will be laid that the bergs will reach the bottom. It is easy for those in rival interests, or for those unacquainted with the physics of the seas, to imagine difficulties. Arctic navigators with whom I have had the pleasure of conversing since my arrival from the voyage of last autumn, agree that, if the cable can be carried into deep fiords on the respective coasts, there will be no danger of interruptions arising from icebergs. I have seen such fiords on the coasts of Labrador and Greenland, and therefore with me the problem is solved.

The land sections are not of serious importance. A telegraph line can be constructed on land wherever the foot of man can be placed. I have built lines over hills and valleys where neither waggons nor beasts could go, and these regions were in the great Mississippi valley, a country having great variety of soil, surface, and climate. I have been in the service some sixteen years, and have participated in the construction of several thousand miles of lines, and have for years served as president, and also in nearly every position known to telegraphy.

The cable will be landed at Thorshaven, the capital of the Faroe group, and from thence a few miles by land to Westerman's haven. The island is hilly—the roads inferior: there is but little cultivation — pasturage good—the people intellectual—religion Lutheran: it sends one member to the Danish parliament, and has a governor, sheriffs, and other officers of state. The climate is about the same as Copenhagen, more mild than Stockholm, Quebec, Montreal, or Boston.

Iceland will be traversed by the line from Portland to Reikiavik. The people are highly educated, and a considerable trade is carried on between them and the Europeans. The French have some 120 vessels fishing on the south coast. They have free trade with foreign countries, and all the inland fisheries are free. The inhabitants are industrious and religious, and have their own local parliament. The country is partially cultivated, but much of the land is covered with lava. The climate is moderate; the ice never interrupting navigation on the south and west coasts. There will be no difficulty whatever in running the telegraph across Iceland.

The cable will be landed in Hamilton's Inlet, Labrador, latitude north 54° 30′. The line will then be run either to the Gulf or to the River St. Lawrence. This country is rolling or hilly, and covered with timber, principally pine, spruce, and juniper. The trees are large, many that I saw being 15 or 20 inches in diameter at the base. There is much grass where the country is open. Turnips, potatoes, and other vegetables are cultivated to a limited extent. The inhabitants are mostly Esquimaux. They are civilised under the teachings of the Moravian missionaries. There is a station of the Hudson's Bay Company on Hamilton's Inlet, about fifty miles from the sea. The coast is hilly and barren. Fishermen from Newfoundland are scattered along the coast, and many are employed in Hamilton's Inlet. The cod and herring fisheries are the most profitable. The country is not much settled. There will be difficulties to be met in the construction of the line, and maintaining it across Labrador; but those difficulties will not be so great as those which have been overcome in other countries, those for example in Newfoundland, and the southern and western States of America. The line across Newfoundland traverses marshy and uninhabited regions, wholly unknown to the world until a few years ago, when it was explored for the telegraph.

The section of the route the least known is Greenland; and, although that part of the country proposed to be traversed is not so cold as the climate of St. Petersburgh, a city of some 700,000 inhabitants, yet there prevails the most erroneous impressions with regard to the temperature of that interesting and wonderful country. Whether it is a continent, or numerous islands extending to the North Pole, are problems yet to be solved. In the southern portion we find green valleys, covered with grass and vegetation, surrounded with mountains towering into the heavens; and these in the morning are covered with white glittering snow, which with the mid-day sun disappears, leaving exposed their blackened minarets and spires. The scenery is grand and picturesque.

The coasts of Greenland are barren hills and mountains. Along the shore are many islands. The fiords penetrate to the interior, ten, twenty, or thirty miles. Some of these bring out ice, others do not. Into one of the fiords which are free of ice will be carried the telegraph cable as indicated on the map. The water is very deep, and no iceberg can reach the bottom, or go far up their meanderings to reach their heads. They do not freeze except in narrow places where there is still water. A cable can be easily laid from the sea into one of these fiords, and when brought to land it can be well secured against native ice, as is the case at many places in America, and on the belts and sounds of the Baltic Sea.

The exact locality where the line is to cross Greenland has not been determined, but it will be in the southern portion, not sixty miles north of Cape Farewell. The particular kind of surface to be traversed—ice-fields, green valleys, or mountain ranges—is not fully known, but in either case no insuperable difficulties can be foreseen. The ice-fields are not like the glaciers of Switzer-

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land. The icy regions of South Greenland are plateaus, decidedly more level than the plateau between Ireland and Newfoundland. I have walked upon the ice plateau, about latitude 61° 40′, and it is not difficult to traverse. It was quite level as far as I went. What it is in the interior, or whether there is ice there or not, no one knows. I found alluvial soil on the ice several miles distant from the sea, and it may have been blown there from the interior. Some twelve thousand deer are killed in the Holstenberg district every year. They disappear in winter. Whither do they go?

The ice travelled over by me was solid fresh-water ice. The snow falls in small quantities and melts away in the day, even in winter. This water freezes at night in winter; in summer it runs off into the sea. I saw on the plateau some considerable collections of water. There were many deep crevices. The thickness of the ice no one has been able to determine. I do not believe it rests upon the earth, but it forms a bridge, and perhaps where I went it was 3000 feet above the level of the sea; or perhaps there was a cavern beneath, 1000 feet between the ice and the earth, exceeding in grandeur the great Mammoth Cave of America, with its two hundred subterranean avenues. This may seem most wonderful, but I have many reasons for believing that it is possible. I heard a waterfall, resembling the rushing of a river over rocks. The bergs from the fiord blinks, I noticed, were clear and clean ice; no gravel or earth either in or on them, excepting those that were near the shore. If the ice were upon the earth in the interior we might expect to find some earth in the bergs. I have seen boulders on bergs, but they came from the glaciers of the north, or from the sides of the blinks crushing against the mountains as the ice moved from the interior.

The inhabitants are Danes and Esquimaux. The Julianahaab district is the most southern in Greenland, and has about 2600 Esquimaux. They are all civilised, and mostly members of the Lutheran Church. There are a few Moravians. The children are baptized, and at fourteen years old confirmed. They have churches and schools, and they preach, sing, and pray. In the principal churches they have organs, and some fine paintings.

The town of Julianahaab has about 300 inhabitants. The people received my visit last autumn with much joy, and illuminated the town. The governor received me at the landing, and told me, "Welcome, welcome, to Greenland!" He invited Mrs. Shaffner to take his arm, and escorted her to his residence. The houses were stone and frame, and covered with slate. It is not cold enough for double windows. They had cows and sheep. The Esquimaux live in stone huts covered with earth, fully as comfortable as many log cabins that I have lived in when in the western forests of America.

The Esquimaux are honest and good-hearted. They never steal unless on the verge of starvation, The men treat their wives well. The children are never whipped. Peace, love, and domestic happiness, seem to be more common to them than to the more civilised races. It will not be difficult to have a telegraph line maintained in Greenland, with the aid of such people. We can command their labour, and there are many Danes ready to enter into the service. I have already had the services of good men offered, and at very moderate salaries. And, in fact, a telegraph line can be constructed across the hills, the valleys, the fiords, and the ice plateaus of Greenland, and it can be maintained thereafter, with much more facility and certainty, than has been done across the plains of Russia, the mountains of Norway, the swamps of Newfoundland, the inundated lands of the Mississippi, the uninhabited forests of America, or the Alpine ranges of Europe.

PROPOSED VICTORIAN TRADES HALL AND LITERARY INSTITUTE, MELBOURNE, AUSTRALIA.

The following extract from an inaugural address delivered by Mr. John Millar, C.E. (honorary architect of the institute), to the members of the institute, at the anniversary meeting held in the temporary hall on the 24th of May, 1860, on the occasion of his presenting a design for a permanent hall. After a few introductory remarks Mr Millar proceeded to say,—

"It will be in the recollection of the trustees of this institute, that immediately after their public announcement and appeal to the members of the profession to which I have the honour to belong, inviting them to contribute original designs for your hall, that I at once volunteered to do so without cost. I did so seeing that from my earliest studentship until the present day, my predilections have been with any movement having for its object the amelioration of the industrial classes.....

When I first turned the subject over in my thoughts as to the particular style of architecture which I ought to adopt I had strong predilections in favour of the perpetuation of a design that would be characteristic of home, and old country associations, by the adoption of 'Old English Architecture. On more mature reflection, however, I considered it unadvisable to adopt such a style, seeing that however beautiful it may be itself, and however admirably adapted, from its high pitched-roofs, to withstand the rigours of a northern climate, it is unfitted for either private residences or public edifices in the sunny south. I then turned my attention to Italy—that land which revels in beauteous examples of architectural effect, in its numerous palatial halls—reviewing these without leaving a lasting impression, seeing that less or more these examples had their origin from the early Greek—to which fountain-head of pure classic lore I have resorted, as having a climate in many respects not unlike our own. This—that is climate—I assert, has more to do with the good or ill effect of particular styles of architecture upon the understanding than is generally allowed. I know—but am not prepared to agree with—the view taken by many travellers in Greece, that the exceeding excellencies of Grecian architecture (so called by the hitherto undisputed opinion of the most enlightened in repute), forbid any approach to equality, either in labour or art, to those magnificent ruins, still existing as the monuments of the refined taste of a great people. Thus, the original productions of former ages bring to comparative shame, by contrast the majority of the mere imitative efforts of our time, in the, mother-country; and why is it so? Simply because the play of light and shade which is necessary to bring out in perfection the beauties of a pure Greek example is not obtainable under the grey and sombre sky of a northern climate; but transplant the true æsthetics of Greek art to an Australian climate, and I venture to prophecy a great success. We must substitute liberal inquiries for pedantic superstition; and sound reasoning for blind and indiscriminate admiration. Until these principles are investigated, and thoroughly understood; until we have ascertained not the *rules*, but the *principles* which directed the Greeks, in vain do we strive to approach them in sublimity of conception....

Melbourne, as a city, is without a parallel in the world's history: it has within the last few years overstepped the usual slow approaches to greatness—has leaped at once into wealth and importance amongst the civilised nations of the earth. New churches, new public offices, new banks, &c., rival each other in taste and architectural display of no mean character, such as would grace even London itself. There is the Senate House, at a cost of £250,000; Post-office, £100,000: Custom-house, £100,000; Treasury, £100,000; Chief Secretary's office, £150,000; Free Public Library, £200,000; University, £100,000;—all connected with the State, besides the numerous banking establishments, not overlooking that rich little gem of Florentine effect, the Savings-bank.

Before proceeding to describe the several accommodations attained by these plans, it will be necessary that I should give you an extract from the report of the committee appointed by the trades to mature a scheme for the erection of a Trades Hall and Literary Institute. It runs thus:—'Having secured the ground, the next subject which engaged the attention of your committee was the consideration of the ways and means for the erection of a building suitable to the requirements of the trades. Since this question has been disposed of, your committee has given its attention to the nature of the building required; and more particularly its internal accommodation. The following, if not complete, may be looked upon as a close approximation to the most serviceable arrangements:—Great hall and ante-rooms, to hold 4500 persons, adapted for concerts, balls, lectures, &c.; library and museum; ten committee and society rooms, the former to accommodate 20 persons each, the latter 400 each; class rooms; refreshment and news rooms; residence for keeper; amusement rooms, for billiards, &c.; store-room; baths; gymnasium.....

Having already given my artistic reasons for adopting a particular style—the pure Greek of the Periclean age—as best adapted for my views, I will proceed to explain the plans, and show how far I have succeeded in embodying all the material requirements of your committee in a building whose extreme measurement is 340 by 135 feet.

The site is 400 by 250 feet, bounded on one side by Victoria-street, and on the other by Lygon-street. The building is placed

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in the centre of the ground, quite isolated, and elevated upon a 'stylobate' or platform of 7½ feet above the general level of the street, and is approached from both fronts by deep flights of steps of 40 feet each in extent. On ascending the southern flight from Victoria-street you gain the level of the principal floor of the building, commencing with a columnar portico of considerable extent, communicating with the entrance-hall 40 by 30 feet; and at the east and west ends of which are circular towers of 30 feet each in diameter, inclosing double flight staircases. From this hall you pass through an inner vestibule, 30 by 20 feet, of two stories in height—immediately communicating with the 'chief feature' of the design—namely, the great central public hall, capable of accommodating 4500 persons; it is in extent from north to south 150 feet, by 90 wide, including the galleries, but exclusive of the organ gallery, which extends some 10 feet farther. The whole height is 75 feet, and I may add that, in point of magnitude, this will be the largest public hall that I am cognizant of, even in Europe. Upon close examination it will be found that every attention has been paid to the ready means of ingress and egress, by the careful arrangement of no less than nine doors of considerable dimensions, all constructed to open outwards with the rush, so that it will be found quite impossible that any accident from overcrowding can ever occur owing to defective arrangements in this particular. Surrounding the hall you have the several committee rooms, as enumerated in the printed schedule, giving separate accommodation to the trades. I have also provided an extra one of larger size for special and amalgamated committee meetings, or as a means of accommodation to all extra trades who may subsequently become connected with the present association. The 'trades society rooms' are four in number, of ample extent, each being 45 by 30 feet, and of corresponding height, each capable of accommodating 400 persons. Running parallel with these committee rooms and the centre hall, you have on one side a colonnade of 130 feet by 20, and on the other a refreshment-room of equal dimensions, together with all the necessary private conveniences on the basement story for the exclusive use of the purveyor and his attendants. At the extreme north, the building terminates with a separate lecture hall, upon a semi-circular plan of 80 feet in diameter, affording ample accommodation for an auditory of 800 to 1000 persons, seated in a series of concentric circles, rising gradually one above the other, thereby affording to every individual within the walls an easy position and an uninterrupted view of the lecture-table, besides distinctly hearing the lecturer; behind whom, and immediately connected with his table and rostrum, is the private laboratory. There are also in connection with this lecture-hall spacious class-rooms provided in the basement. The auditory portion of the hall is approached from both the upper and lower floors; first from the vestibules east and west parallel with it, also from the gallery over, which is appropriated as a 'building museum,' in extent 80 feet by 20.

There are three principal staircases provided,—two of them at the south entrance end of the building, and one inclosed within the radiating antæ walls of two circular towers of 30 feet each in diameter, each having a central flight of steps to mid-height, where they severally branch off into double flights, so, easily reaching the level of the upper floor, upon which the library 35 by 30 feet, news-room 35 by 30, &c., are planned; as also the audience galleries, 15 feet in width, of the great central hall, intended exclusively for the occupation of the wives, daughters, and children of the members. This gallery also communicates, at its north end, with the organ gallery and the third principal staircase, 20 feet by 20, also having double flights of steps, from the landings of which the museum, 35 feet by 30, and billiard-rooms, 35 feet by 30, and other requirements of lesser note, are reached.

From the news-room at one end, and the museum gallery at the other, there is a thorough communication with a divan, a space of 130 feet by 20, over the refreshment hall, which, from being exposed at the eastern side to the open air, will give the members all the enjoyment of a smoking saloon, without incurring the ill effects which its contiguity would otherwise entail upon those members who do not use it.

There is a clear uninterrupted view internally throughout the entire length of the building, from the back gallery of the lecture-hall, through the building museum, staircase, great hall, inner vestibule, entrance-hall and Victoria-street portico, a distance of 340 feet.

The basement story consists principally of a large bonded store, underneath the central hall; whilst the other necessary apartments not heretofore enumerated are amply provided for there,—such as the class-rooms, residence for keeper, baths, lavatories, &c.

As to the elevations, after what I have explained of the general arrangements of the plans, it would be superfluous to take up your time by any lengthened description of the several façades, simply trusting that they tell their own tale; and that the unities of style, the connection of the parts, together with the severe tone of classic propriety adopted, has been carefully preserved throughout. The general effect in execution of the central portico, with its surmounting pediment, &c., fronting Victoria-street, taken together with the deep-shadowed recesses of the entrance, will, I feel assured, contribute materially to enhance the picturesque effect, and be such as to give to that part in particular a richness and power which will strongly yet harmoniously contrast with the Campanile Towers, 80 feet in height, with which the portico is flanked.

The general effect which I have throughout endeavoured to obtain, is that of simple unassuming grandeur from a bold and massive outline, without depending upon the aid of meretricious ornament of any kind, and which in every instance I have carefully eschewed.....

Permit me to add, that the greatest reward you can confer on me, is your assurance that you consider the design adopted as worthy of the cause you have espoused, worthy of the age in which we live; and that though it may not be all that might be desired, not so perfect in its every feature, nor so faultless in detail, as would realise the beau-ideal of perfect art, yet that by its erection we shall honour and dignify labour."

ON SOME REGENERATIVE HOT-BLAST STOVES WORKING AT A TEMPERATURE OF 1300° FAHR.*

By Edward A. Cowper, C.E.

(*With an Engraving.*)

The practical utility of hot-blast has been so thoroughly appreciated since its first introduction by Mr. Neilson in 1829, that it now needs no advocate to recommend it to experienced iron-masters. Many plans of hot-blast stoves have been suggested and tried, and various opinions have been expressed on their merits, as it has frequently happened that the same constant care and watchfulnesss have not been exercised at different works when using stoves of a similar description. It has been found by many careful observers that the results from the blast furnace are so greatly improved by raising the temperature of the blast, that ironmasters have often tried how far they could go in obtaining a higher temperature, and have of course soon arrived at a limit, from the destruction which ensued of the cast-iron pipes; and it is obvious that there must always be a wide difference between the temperature of the air-heated inside a cast-iron pipe and the fire outside the pipe heating it, as there will be the difference in temperature between the fire and the pipe, together with the difference in temperature between the pipe and the air passing through it. These differences must be considerable, in order to insure a tolerably rapid conduction of the heat; so that in no case can the hot-blast approach at all near to the temperature of the fire, nor indeed would the cast-iron stand if anything of the sort were attempted; in fact, it is well known what care is necessary in damping the fires of common hot-blast stoves when the cooling effect of the air inside the pipes is taken away by the blast being stopped at tapping time or on any other occasion. The temperature at which the products of combustion pass away from ordinary stoves is from 1250 deg. to 1500 deg., whilst the blast is heated only to about 700 deg. The economy of fuel for real work done must therefore be very low, as the products of combustion must pass away much hotter than the temperature obtained in the blast, say about double the temperature; and when it is attempted to obtain economy in the blast furnace by increasing the temperature of the blast, economy is further sacrificed in the stoves, by the greatly increased amount of heat which must necessarily pass away: hence the hotter the blast, the greater is the waste of fuel in heating it in the ordinary stoves.

In the plan of hot-blast stove to which it is now wished to call

* From a paper read at the Institution of Mechanical Engineers.

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attention, the principle of Mr. Siemens' regenerative furnace is adapted for the special purpose of heating blast, and the stove is inclosed in an air-tight case or skin of metal; by which means it is possible to obtain the blast of as high a temperature as the most refractory metal will stand, and to abstract the whole of the heat from the fuel used. This result, it should be observed —great economy with very high temperature—is obtained entirely without any iron surfaces being exposed to an injuriously high temperature, as the whole of the cast-iron pipes and mains of ordinary stoves are entirely done away with, and only fire-brick or other good refractory material is exposed to the fire; so that the whole of the cost and wear and tear of the cast-iron pipes is at once avoided.

It may be well first to refer to the principle of the regenerator, which consists of a chamber in which are placed a large number of pieces of any refractory material at a small distance apart, so that the heat from the fire can be passed through the chamber amongst them: they thus become heated, but not equally; for those nearest the fire absorb the greatest amount of heat, then those next to them a somewhat less amount, the next still less, and so on, until at last there is no useful heat left in the products of combustion. For so long as the pieces of refractory material are at a lower temperature than the products of combustion, they will continue to take up some heat, and thus it is impossible for any heat to escape or get through; unless indeed the heating process were continued so long that the whole regenerator became hot completely through from end to end, which of course might be done, though it would take many hours to accomplish it. The next operation is to abstract or utilise the heat so taken up by the regenerator: and this is accomplished by shutting off the supply of heat from the fire, and turning the air to be heated through the regenerator in the opposite direction; so that it comes in contact first with the cool end of the regenerator, and therefore commences by taking up only a little heat; then as it strikes the next set of pieces of material in the regenerator it takes up a little more heat, as they are a little hotter than the first; and passing onward it takes up more and more heat as it comes in contact with each stratum of heated material; until the air issues from the hot end of the regenerator at very nearly the temperature of that part, having been again and again broken up into minute streams, and been heated by direct contact with the very surfaces of the material which had previously received the heat: so that whatever heat is first gradually put into the regenerator is again as gradually taken out by the air when passed through in the opposite direction.

The specific heat of common fire-brick has been found to be very great, its capacity for heat being about equal to that of copper, bulk for bulk, and therefore many times as great as that of copper, weight for weight. In comparison with water, bulk for bulk, the specific heat is also nearly equal; and the temperature of the fire-brick at the hot end of the regenerator being raised to about ten times that of boiling water, this makes the total capacity of the regenerator near the hot end nearly ten times that of an equal volume of boiling water. Now as the specific heat of air is small, being only one-fourth that of water, weight for weight, a small quantity of heated fire-brick will suffice to heat a very large volume of air. This is confirmed by practice in the stoves now at work, which have only a moderate quantity of fire-brick in them, but the currents of heat and of cold-blast require to be changed only once every two hours to produce a very regular temperature of hot-blast; and by increasing the quantity of fire-brick or changing two pairs of stoves alternately, much longer times of changing might be adopted, or even greater regularity of temperature might easily be obtained. Fire-brick is also a good refractory material, and is cheap; it is therefore well adapted for the purpose of filling the inside of the regenerators.

The new regenerative hot-blast stove, heated by coal fire, is represented in Plate XXV., where Fig. 1 is a vertical section and Fig. 2 a sectional plan of one of a pair of experimental stoves erected at Messrs. Cochrane's works at Ormesby, near Middlesborough, where they have been working regularly for more than two months, heating nearly 1000 cubic feet of air per minute up to 1200 deg. or 1300 deg. Fahr. Fig. 4 is a plan of the pair of stoves placed side by side. These stoves are heated from the bottom by coal fires A, and the heat passes upwards through the regenerator B, by which the greater part of it is absorbed, the residue finally escaping at the top through the valve C into the flue leading to the chimney. The fireplace A is provided with a sliding firedoor D, made hollow, with water in it, which runs to and fro on rollers, and when shut incloses the fire entirely as well as the ashpit; and being planned to fit its frame, immediately that the pressure of the blast is put on the door is pressed against the frame and is made air-tight. The cold-blast valve E at the top of the stove is an ordinary sluice-valve; and the hot-blast valve F is a cast-iron valve of hemispherical form, the better to resist the heat to which it is exposed; it does not slide on its face, but is simply lifted up and down, being made flat at the edge and sitting on a rounded seat. This valve answers very well, though for very high temperatures such as 1400 deg. to 1800 deg. or more, which it is proposed to reach eventually, it is intended to have water inside the hot-blast valves, as shown in the enlarged vertical section of the hot-blast valve, Fig. 3, where the valve is made of two wrought-iron hemispheres welded and turned on the edge, and supplied with a flow of water like an ordinary water tuyere. Whilst heating up, the sliding firedoor D and the chimney valve C are open; and after two hours these are shut, and the blast-valves E and F opened, allowing the blast to pass through the regenerator B in the downward direction for two hours, during which time the other stove is being heated, the pair of stoves being situated side by side, as shown in the plan, Fig. 4.

The regenerator B may be composed of any good refractory material in pieces, and is therefore constructed of firebricks laid open, in the manner shown enlarged in Figs. 5, 6, and 7. The temperature produced by the fire is probably about 4000 deg. Fahr., though no exact experiments have been made on this for want of an accurate instrument; and the action of the regenerator is so perfect that the heat escaping through the chimney valve C is only 150 deg. to 250 deg.: indeed the hand may be put right into the flue without the slightest injury, showing that practically all the heat is absorbed by the regenerator. The cold blast entering at the temperature of the atmosphere, or a very few degrees above, owing to its compression to 3 lb. pressure per square inch, becomes heated in its passage downwards through the regenerator to 1300 deg., and the temperature varies only about 100 deg. or 150 deg. during two hours' work with one stove. These experimental stoves however were never intended to work for more than one hour changes, as they have only a moderate quantity of firebrick in them, being made out of two pieces of wrought-iron cylinder, 7 feet 6 inches diameter, that were already in existence. These stoves have now been working for more than two months at the temperature of 1300 deg., supplying one 3-inch tuyere of a large furnace, and delivering nearly 1000 cubic feet of air per minute. The melting of lead by the blast is a common test for the temperature of the blast in ordinary hot-blast stoves, and with a hotter blast zinc is used as a test; but with such hot-blast as is obtained by the regenerative stoves it is necessary to use a metal that melts at a much higher temperature, and therefore antimony is employed, which is melted in some six or seven seconds and often in even four or five seconds. The whole of the hot-blast main conveying the blast from the stove to the globe-pipe near the furnace is lined with firebrick; and the muzzle and globe-pipe that are not so lined keep red-hot.

Several experiments were made with these stoves last year, but owing to the great distance that the hot-blast had to travel through pipes not sufficiently lined with firebrick, several hundred degrees of heat were lost in the passage, since upwards of 65 feet length of cast-iron pipe was kept at a good red heat by the passage of the blast through it. The temperature of the blast at the muzzle in these experiments was often 1250 deg., whilst at the stove it was 1500 deg. and even 1600 deg.; and at one time, when the stove was pushed too much through carelessness, the blast was heated to within a few degrees of 2000 deg. With regard to the economy of these fire-heated stoves, it may be judged of by the consideration of the fact, that the heat passing away into the chimneys of ordinary hot-blast stoves amounts to about 1250 deg.; whereas with the regenerative stoves it is only 200 deg., or even less.

The mode of measuring the temperatures obtained was by an accurate pyrometer on the principle of that by Mr. John Wilson, though perhaps slightly improved in detail. The pyrometer is shown in Figs. 8 and 9, and consists of a copper vessel G capable of holding rather more than a pint of water, and well protected against radiation by having two double casings around it, the inner containing air, and the outer filled with felt. A good mercury thermometer H is fixed in it, having in addition to

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the ordinary scale a small sliding scale I, graduated and figured with 50 deg. to 1 deg. of the thermometer scale: there is also provided a cylindrical piece of copper J, accurately adjusted in size so that its total capacity for heat shall be $\frac{1}{50}$th that of a pint of water. In using the pyrometer, a pint of water is measured into the copper vessel G, and the sliding pyrometer scale I is set with its zero at the temperature of the water as indicated by the mercury thermometer H; the piece of copper J is then put into the current of hot-blast the temperature of which it is wished to ascertain, and is allowed to become heated for about two minutes, when it is quickly dropped into the water in the copper vessel G, and raises the temperature of the water in the proportion of 1 deg. for each 50 deg. of temperature in the copper; the rise in temperature may be read off at once on the pyrometer scale I, and if to this is added the actual temperature of the water as shown on the scale of the mercury thermometer, the exact temperature of the blast is obtained. This pyrometer is found to be far more accurate than any others for high temperatures, that is such temperatures as will not melt platinum.*

REVIEWS.

The Carpenter and Joiner's Assistant, Parts 21, 22, 23, and 24. London: Blackie and Son.

THE above parts complete this excellent work, which, unlike many of its class, has maintained to the last the pledge with which it set out, of being at once a comprehensive, well-digested, and as far as possible novel elucidation of the subjects on which it treats. As these have been brought before our readers from time to time, accompanied by such remarks as they seemed to suggest, it will be unnecessary to repeat our approving verdict as to the skill and judgment which have been manifested throughout. In the first of the four numbers under consideration will be found a treatise on windows and shuttering, concise, yet sufficiently detailed to illustrate the leading principles of their construction; also an interesting article on "Labour-saving machines," from which it appears that the first attempt to construct a planing machine was (according to Mr. Molesworth) made by a Mr. Hatton in 1776, and the next attempt by Sir Samuel Bentham in 1791. It was not till the end of the last century that circular saws were introduced into England, although they were previously used on the continent for small work in all kind of materials.

"When Sir Samuel Bentham was in Russia, previous to the date mentioned, he had made considerable progress in contriving machinery for shaping wood, so as to insure accuracy and save manual labour. Besides the general operations of planing, rebating, mortising, dovetailing, grooving, bevelling, and sawing in curved, winding, and transverse directions, he had completed, in the way of example, an apparatus for preparing all the parts of a highly-finished sash-window; another for preparing every part of an ornamental carriage-wheel, and nothing remained for finishing the work of the joiner or wheelwright but the putting the several component parts together. In 1793 Sir Samuel Bentham patented several inventions, and as Mr. Molesworth well says, 'had his ideas been carried out and the appliances of engineering been more perfect, he would doubtless have introduced many of those inventions which were years afterwards brought out and patented as new.'

In 1802, Mr. Bramah patented machinery for producing straight, smooth, parallel, and curvilinear surfaces on wood. In his planing machine the cutting tools were fixed in apertures near the circumference of a horizontal wheel, moving with great velocity on a vertical axis, and the timber laid on a horizontal carriage was moved forward under their action. In 1807, Mr. Brunel's famous block machinery was set to work in Portsmouth dockyard. It is not necessary here to trace the progress of conversion of timber by machinery; suffice it to say that Thompson's machinery for sawing, guaging, and grooving and tonguing floor-boards was in operation in 1826; and in 1827, Mr. Muir, of Glasgow, patented a machine for working flooring-boards, which has since served as a model for those subsequently introduced in Britain. In this machine the bottom of the board was roughly planed by a rotatory adze, while another similar adze operated on the upper surface. The board then passed between two fixed cutters set obliquely, which removed a shaving of the length and width of the deal, while two revolving cutters or saws made the sides parallel, and two other cutters grooved or tongued the edges."

"We note a few practical points to be observed in the construction of these machines. In machines with revolving cutters the general opinion is, that the greater the speed of the cutting-tool the better will be the quality of the work. The practical limit, however, appears to be between 2500 and 3500 revolutions per minute. A higher velocity heats the bearings, destroys the balance, and causes injurious vibrations. To produce a good result the travel of the work should be very slow relatively to the travel of the cutters. In some of the planing machines the cutters revolve with a velocity of 7000 feet per minute, while the work advances at the rate of only 30 feet, but as a general rule the work travels about $\frac{1}{20}$ of an inch for each stroke of the cutters. In order to withstand this high velocity, the framing of the machine requires to be perfectly constructed. It should be of hard wood; and Mr. Molesworth directs—'that the joints be not made so as to depend simply on mortise and tenon; they should be shouldered in.' 'The bearings are sometimes made of an alloy, composed of 100 parts tin, 10 parts antimony, and 2 parts copper. In forming them the spindle is accurately fitted in its place, and the alloy is cast round it into an iron shell, which forms the plummer block. The parting of the base and cap is made by inserting a thin sheet of iron in the proper position.' 'Another peculiarity is the method of securing steadiness in high-speeded shafts; this consists in cutting in the journal a succession of angular threads, with angular grooves between. The alloy is cast round the journal as before, and great steadiness of action is secured; whilst the oil remains in the bearings without difficulty. An adjusting axle box is also much used; it is centered on two set screws, so as to allow it to turn slightly in the event of the opposite bearing being unevenly worn, and thus the extra wear and chatter which would ensue at high speeds are obviated.'"

"Staircases and handrailing," treated of in Section 7, opens up an intricate subject, here copiously illustrated by mathematical and other diagrams, which will be studied with advantage; and due credit is accorded to the late Peter Nicholson for his ingenious system and practical solution of difficulties, especially as regards cylindrical sections, and the proper method of producing the section of the cylinder through any three points on its surface. In the course of the argument some improvements are stated to have been made by the author of the work before us, the merits of which are detailed, and contrasted with those of former methods.

Section 8 is devoted to the "Projection of shadows, perspective, and isometrical projection," in which the leading principles are clearly laid down, and primary rules given for their practice. The explanatory diagrams, too, are copious and clearly defined. We are surprised to find the use of the centrolinead so discouraged, when the conveniences it affords so far outweigh the trouble of adjusting it, which is here stated to be its great drawback.

As a termination to the whole, a copious index, comprising also a useful glossary of terms used in architecture and building, interspersed with an abundance of illustrations, will be found by no means the least useful section of the book, as it has evidently been compiled with the utmost care, and contains a vast amount of well-digested information. One great recommendation of this book is the variety of illustrations derived from foreign sources hitherto unpublished, especially in the department of carpentry, which contains examples of some of the best timber constructions executed not only in Great Britain, but also on the continent of Europe and in America.

A Rudimentary Treatise on Clocks and Watches, and Bells; with a full Account of the Westminster Clock and Bells. By E. B. DENISON, M.A., Q.C. Fourth edition, re-written and enlarged.—London: John Weale. pp. 434.

This volume forms one of the series of small scientific works, now so well known, which Mr. Weale has for several years past been engaged in publishing; and it will be found in many respects one of the most remarkable books of the series. The subjects of clocks and bells are both included, and the book might be considered as two distinct treatises in one volume, the matter respecting bells being kept distinct from the other portions of the work. "A full account of the Westminster Clock and Bells" might be expected, coming from Mr. Denison, to be both curious and controversial, for there have been many disagreements respecting them, and some misfortune, and much fault-finding, in all of which Mr. Denison has had a great share. In this volume the author goes into the whole history of these transactions, and this portion of the book, though less permanently valuable than any other, will probably be read by many with much interest, and not a little surprise.

The style of writing is easy and very readable, whilst the

* The concluding portion of Mr. Cowper's paper, which relates to regenerative hot-blast stoves to be heated by gas, will appear in our next, accompanied by the necessary illustrations.

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scientific details, and the accounts of mathematical and arithmetical calculations which the work contains, are very clearly and accurately put, perhaps more so than could have been expected from any but a zealous amateur of the art.

It may best serve to give an idea of the nature of the book if we attempt to analyse the manner in which the subject is developed. At the outset a concise account of the nature of all time-keepers, and of the difference between sidereal, solar, and mean time, is given, followed by a few words on sun-dials, and an account of an equally simple and practical method of making and fixing a meridian dial. Then follow a connected series of observations on time-keepers, beginning with water and sand clocks, and going through all the mechanical contrivances that have superseded them. Above one hundred pages are devoted to pendulums and escapements alone, succeeded by descriptions of the going part of clocks, their chimes, dials, hands, &c., concluding with the *description* of the Westminster Clock. A notice of watches and their works, balances, and escapements follows, and then what is called the *history* of the Westminster Clock and Bells; the concluding portion, and perhaps the most generally valuable to our readers, being an account, occupying some forty pages, of bells and bell-hanging in general, a subject upon which information is both scarce and valuable.

That the book is free from bias is not for one moment meant to be asserted, but a discriminating reader will find in it concise and intelligible information on all the heads we have enumerated; though he will probably have his misgivings as to whether the work of one well-known firm which has been much connected with Mr. Denison for many years, can have been always so far superior to that of all other makers of clocks as the unmeasured praise of it which this volume contains would at first sight lead one to believe.

We subjoin some of Mr. Denison's introductory observations on Public or Turret Clocks: they are in themselves valuable, and are a fair sample of the book.

"It may be supposed that as the work of these clocks only differs from that of house clocks in the size of the hands and weight of the hammers they have to move, you will only have to enlarge the machinery and the business is done. But there is a very important fact in the way of that conclusion: viz., that as you increase the strength of the machinery you increase its weight in a ratio as much higher as the cube is higher than the square of any of its dimensions; and when you increase weight you increase friction, and friction is a word which ought never to be long out of the mind of a clockmaker, or at least of a clock-designer, inasmuch as the time-keeping part of a clock is the only machine whose sole business is to overcome its own friction, resistance of the air, and variations of heat, and to do that in a constant and uniform manner. And there is this further difference between large and small clocks: in small ones the force or weight required to work a hammer of an ounce or two is generally about the same as is required to keep the pendulum going, and so the two 'parts' or trains are about equal in strength; whereas in large clocks the lifting of the hammer generally requires a great deal more power than driving the hands and pendulum, and therefore ought to have much heavier and stronger machinery. Nevertheless the object of some clockmakers seems to be to make the going train of large clocks as heavy and the striking train as light as they can, I suppose from the ridiculous love of uniformity which people have been taught for many years to admire in the great constructive art of building, and which is still more absurd in mechanics, except where the work to be done by two different machines is the same."

The subject of Dials is of more general interest to engineers and architects than the details of the construction of timepieces may be; and we make no apology therefore for extracting part of the observations and a table given under that head.

"I have already alluded to the mistakes made by architects in not providing proper accommodation for clock and bell machinery, even in towers expressly designed for them. In most cases this only causes unnecessary expense and derangement of the works; but their ignorance of the proper size of dials often causes more serious inconvenience. Mr. Vulliamy did something towards correcting the common mistake of providing insufficient space for dials, in a pamphlet called 'Considerations on Public Clocks,' which he published some thirty years ago. But it is probably forgotten now; at any rate it has ceased to bear much fruit, when one sees such dials as those of the Leeds Town-hall planned deliberately, in spite of previous warning, of about half the area proper for their height according to the well-established rule that the diameter should not be less than $\frac{1}{10}$th of the height from the ground. In order that anybody may judge of this for himself I will give a list of the sizes and heights of some dials, which I happen to have got from Mr. Vulliamy's pamphlet and other reliable sources; including one other besides those of the Leeds Town-hall, which you will see, if you go to look at it, is evidently too small.

	Dials.	Diameter. ft.	in.	Height. ft.
Mechlin	1	40	0	.....
Westminster	4	22	6	 180
St. Paul's Cathedral	2	17	0	 126
Shandon Church, Cork	4	16	0	.....
Scarborough Old Church ...	1	12	0	On a hill
St. James's Church, Piccadilly	4	10	0	.....
Bow Church	2	9	0	 70
Manchester Infirmary	4	9	0	 80
Royal Exchange	4	9	0	 90
St. George's Church, Leeds ...	3	8	4	 57
St. Martin's in the Fields ...	4	8	0	.....
Horse Guards	2	7	5	.....
Marylebone Church	3	7	0	About 60
St. Luke's, Chelsea	4	6	10	 72
The Queen's Stables	2	6	10	About 50
TOO SMALL.				
St. Pancras' Church	1	6	6	 100
Leeds Town Hall	4	11	0	 150

The Westminster and St. Paul's dials, you observe, and some others in this list, considerably exceed the proportion of $\frac{1}{10}$th their height, and certainly do not look too large; and I have no difficulty in saying that that is the least size which a public dial ought to be, except in some unusual positions where they can only be seen a very little way.

An equal though not an equally incurable mistake is often made in the size of the figures. People seem to fancy that you see what o'clock it is by reading the figures; as if any single figure which you see in a clock dial indicated the figure which you read off, except for the hour hand, and it is seldom that you do not know the time within an hour. You see the long hand pointing to VIII, and you say, 'twenty minutes to something.' Indeed for the hours as much as for the minutes everybody really judges from the position of the hand, and twelve large spots would do as well or better than figures. I have a clock, and there is another in the Athenæum club, with the gravity escapement, purposely made without any figures at all round the principal dial, only twelve strong marks; and I never found anybody who even observed the fact that the figures were absent until it was pointed out to him, or complained of the want of them then. But you may ask, what harm do large figures do? They practically contract the size of the dial in two ways; first by contracting the plain surface in the middle, over which the hands are most distinctly seen; and secondly, the larger the figures are, the more they run into each other and fill up the space of the figure ring itself, and make it still more difficult to distinguish the place of the minute hand. I have come to the conclusion after various trials, that the figures and minutes together ought not to occupy above one-third of the radius of the dial; the figures may be two-thirds of that one-third; and the minutes from half to two-thirds of the remaining one-ninth of the radius, with every fifth minute strongly marked by a larger spot than the others. The Westminster dials might have been clearer considering their great size. They are not of my design, except that I gave the architect some suggestions for them, which are partly followed and partly not followed. They are unnecessarily confused with iron frame-work, and the clear space is unduly contracted by some broad rings supposed to be ornamental.

The only colours that seem to answer for dials and hands are black or dark blue with gilt figures and hands, or some very light coloured ground such as white glass, with black hands and figures. Good gilding will last fifteen or sixteen years, as at the Royal Exchange, in the worst London atmosphere: the Marylebone Vestry have to re-gild their church clock hands every four or five years apparently. Gilt hands on a light ground are a complete failure. The external counterpoises, if there are any, should be painted the same colour as the ground of the dial, except where they are very short in proportion to the hands, as at Westminster, in which case they cannot be mistaken at any distance for the hands themselves, and practically increase their visible length.

Dials may be made of almost anything—stone, slate, plaster, brick, iron, copper, and many old ones are made of wood, which however is the worst of all, as it always shows the joints. In many cases the stone of the tower makes the best dial. Generally it requires painting; but if it is such a stone and in such a position that it will keep nearly white, it will do very well with only the black figures and minutes painted on it, and black hands, but by no means gilt ones. Dials on brick-work must of course be painted. It is quite a mistake to suppose that a dial requires quite a very smooth surface. Some of the most distinct I have ever seen are painted on rather rough stone-work; and brick will do as well, either all flat, or with the figure circle a raised ring of iron, or of any plaster that will stand. There are many dials of cast-iron; but I should never make more than the figure ring of iron, unless there is a large hole in the wall which wants covering; and even then it is generally better to fill it with glass, which has all the effect of a dark ground outside and is often convenient within. Slate makes a good dial, but if it is not painted it becomes a pale grey colour. I believe 6 feet diameter is the largest size that can be got in one piece, but the joints are almost invisible if well done.

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Copper dials are the commonest of all, and up to a moderate size probably the cheapest, except of course when the dial is simply painted on the wall. But they are generally made in the very worst form that could be invented, viz., convex: the effect of which is that the point of the minute hand is thrown a long way off the dial, and the parallax is so great that you cannot tell what it is pointing at, except when it is nearly vertical; and moreover the convexity distorts the upper half of the dial when seen from below, as a public dial always is. To avoid these evils Mr. Vulliamy never used copper dials when he could help it, but flat ones, generally of slate, with the middle countersunk for the short hand to travel in, leaving the long hand to lie close also to the raised figure ring. And this is a very good form for dials of anything but copper.

Concave dials. It occurred to me a few years ago that all the convenience of the light copper dials might be got, with even more closeness of pointing than in a flat one, and with as much stiffness as the convexity gives, and with less distortion of appearance, simply by making them concave instead of convex. If you draw a vertical section of a convex and a concave dial, and three lines of sight, from the top, the bottom, and the middle of each, to a spectator in the street, you will see at once that the convexity makes the upper half appear much smaller than the lower, whereas in the concave one the two halves appear even more alike in size that in a flat dial; and the closeness of the hand point is evident. Mr. Dent, and Mr. Potts, of Pudsey near Leeds, a considerable maker of church clocks in Yorkshire, immediately adopted these dials, and many of them have now been made, and some old ones altered from convex to concave, with great improvement in appearance and distinctness. The dials on the platform at King's Cross Station, and the larger one on the Railway Works at Doncaster, were the first of this construction, and you may see from them how much better concave dials looks than convex ones, and how close the minute hand is to the figures."

With these extracts we propose to conclude our notice of that part of the book which treats of clocks. On a future occasion we purpose making some observations respecting Mr. Denison's views on the subject of bells, and on that part of this valuable little work which relates to the Westminster Clock and Bells.

ON THE TREATMENT OF SUBSERVIENT FEATURES AND ACCESSORIES EXHIBITED IN SOME LATELY ERECTED BUILDINGS.

Mr. Editor.—Continuing the observations made in my two former letters to you on this subject, given in your numbers for June and March last, the next building to which I would direct notice is the manufactory of Messrs. Lavers and Barraud, in Endell-street, Long-acre. This is one of that class of designs for the introduction of which there has been lately a kind of *furor*, and which in a similar phase to that here exhibited has been designated Italian Gothic. This building consists of four stories, the main front being towards Endell-street, and a return in Brownlow-street. The material generally is red brick, in which bandings and other ornamentation in black and yellow brick is interspersed. Stone is introduced as window heads and cills, as springers to some of the arches, and as set-off to the plinth; there is also a stone mullioned and traceried window in the upper story of the return front, and a stone band or string runs beneath the lights of the third story.

There is a flatness in the general appearance of the main construction and minor features of this building which very much detracts from its effect, and which is certainly no characteristic of Italian architecture, whether Gothic or otherwise. The elevation is one continuous plane, unbroken by moulding or projection of any kind beyond the corbel table at the eaves. The recess of the door and window openings, excepting at the dormers, shows only the ordinary 4½-inch reveal. Relieving shadow or deep shade is as a consequence wholly absent. Unbroken face carried to the extent shown at Messrs. Barraud's is a mistake, and particularly in the case of a building in which the several stories are so distinctly pronounced as in this; nor am I cognisant of the existence of legitimate authority for a departure from the practices generally observable in this respect in the Italian buildings of this type.

This point however, with several others in the same building, may be considered, perhaps, as rather involving a matter of taste referring to the general design, than as having relation to the particular features on which it is the object of this paper more directly to comment. Of these latter or their treatment it may be observed, that the way in which the finials of the dormers is managed, as well as their character, is very objectionable. They are formed simply by an upright of squared or bar-iron, with a kind of knot of attached arms or pieces of the same metal of less substance joined on and curved downwards after a very ordinary fashion; and they rise at once from the ornamented ridge-tile without any base such as these terminations usually and properly have. Neither are they in fact verge ornaments or completions, which is their common and correct expression, for they stand back some distance from the face of the verge of the gable, and appear as if merely screwed to the ridge-board; and as a consequence break through the ridge ornament, instead of forming according to the more legitimate fashion a terminal or end finish of the same.

In relation to the gables of the dormers on which these pinnacles stand there is also an omission which, as affecting æsthetically the requisite substantiality of appearance as well as completeness of the former, it is desirable should have been admitted. The slating which covers the gable is projected, according to received and general custom in such cases, slightly over the front plane of the wall, without any under-fillet or over-sailing for the reception of the same. In old examples there is generally found some provision of the kind taking the form of a moulding or plain splay of stone or other material, following the rake of the gable, and filling the angle made by the wall and the projected roof covering. In the present case the absence of such an introduction gives a very naked and papery appearance to the verges or edges of the gable, and which, in the case of the employment of slate as a covering, is necessarily, as compared with tile, sufficiently incurred, and needs to be qualified more or less. Practically considered also, the omission of an under verge-course of some sort is an error, for its presence enables the slated edge more conveniently to be tilted for the purpose of directing the run of the water falling on this point backwards, and so preventing a drip or overflow from the face of the gable. The consideration of and provision for this is sensibly visible in some of the old verges, particularly in timber construction, and its principle is further carried out in stone copings similarly applied, which are frequently bedded or worked to fall, and so deliver to the roofs behind them. In the latter cases this is in effect a lifting of the verge-course, as well as virtually a retention of it in a modified form.

Again, no provision appears externally for the conveyance of the rain-fall from the roofs. The corbelled eaves cornice probably supports and hides a sunk gutter from which the water descends inside the building. A good treatment of the rain-pipes is observable in the schools now being erected at the north-west corner of the same street, and something similar might have been admitted here with advantage. There is no reason why that which is a natural want in a building should be put out of sight. These should properly be made to aid the true expression as an undisguised and studied matter in all its essential parts.

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THAMES EMBANKMENT.

We have received an elaborate and ingenious letter from an amateur correspondent under the signature of D.B., who will find in our No. 268 (July 1856), vol. xix., everything he has recommended clearly put forward;—the embankment, the egg-shaped intercepting sewer, and one lower still, that is, "7 or 8 feet below low-water mark"—quite low enough when continued on, to pass at a lower level than the cills of the dock-gates, which it is possible may not "have been dreamt of" before the appearance of our remarks on the subject in 1856. Thirdly, all the old sewers, by that paper, were to be preserved in their working state—not reversed, to be made to run to the Strand and Fleet-street—and improved on as time and means would admit. D.B.'s difficulty of coffering—"not to be thought of, unless moveable," judiciously added to his observation—is got over, inasmuch as deep-piled coffers would only have to be used in the very trivial portion of deep water to be worked through: there being two kinds of moveable coffers particularly applicable to the circumstances of the Thames, viz., the loaded, or crib coffer, as it has been called, so successfully used at the Montreal Bridge—very suitable for flat and shallow places; and the apron or stockade coffer, not so generally known or adopted as it might be, not being one-fourth of the expense of either of the preceding, and although not well suited to very deep water, can be used on shelving ground or a face of rock, where neither of the previous modes would be at all practicable, and very easily removed. Lastly, in our paper referred to, although the material of the

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tunnel or intercepting sewer is not exactly specified, hard brick, as in the Thames Tunnel, &c. was implied and intended; but Mr. Austin and many others have suggested cast-iron, but none of so confined or inefficient a size as 6 feet in diameter, recommended by D.B.; nor would his method of laying with "water-tight head," be practicable, as its buoyancy, so placed, would act like the metallic tubes in ships' life-boats, and he would find himself and tubes, we fear, "at sea" again.

We would ourselves avoid the pumping of the sewage, which we are of opinion can only be done effectually by pumping up the water, after its riches previously held in suspension should have been left behind for agricultural purposes; but we greatly fear that D.B., by proposing that the sewage should flow out upon the land, as at Edinburgh, &c., has omitted to consider that should his tunnel pass below the level of the dock-cills, say about forty feet below the level of the top of high-water,—that, as it should have at least the same inclination, if not more, than that of the bed of the river, at his terminus it would be equally below high-water, and, either thick or thin, it would have to be lifted by pumps or other contrivance to the surface, before it would flow on land anywhere. So that in the end, although abjuring pumps, he would have to take to them. We had deemed it almost unnecessary to add, after the report of the parliamentary committee so strongly opposed to it, that the sinking under the Strand and Fleet-street, and the reversal of all the cross-sewers in the private streets, can scarcely be thought of; and D. B. will see that in our paper of July 1856, "the danger of bringing down St. Mary's and St. Clement's churches" is particularly alluded to.

HEINKES' DIVING DRESS AND APPARATUS.

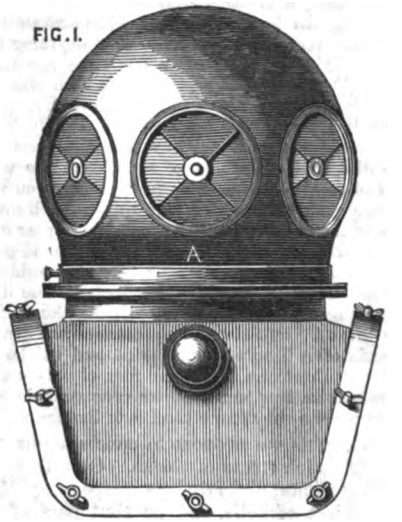
In the ordinary diving apparatus and helmet great alterations have been effected from time to time by the various makers. The improvements introduced by Mr. Heinke, some of which are shown in Figs. 1, 2, and 3, are based upon long experience of the defects complained of in ordinary apparatus. The submarine dress, as manufactured at that period, was exhibited at the Great Exhibition in Hyde Park, in 1851, and obtained the award of a medal; since that time several additional improvements have been made, and so nearly perfect may the apparatus be now considered, that there are few persons who would hesitate to go down in the dress after once seeing it used.

Among the most prominent of the improvements is that of the eye-frame, to which is affixed a brass slide, so contrived that in case of accident to the glass the diver can immediately close it, and thus save himself from drowning. A double valve fixed in the front of the gorget enables the diver to descend and rise at pleasure, with the whole of his gear, which weighs upwards of 200 lb.; in fact it places the whole apparatus completely under his control; and protects him in case of anything happening to the air-hose, as by its means a sufficient quantity of air to support respiration for ten minutes can be contained in the helmet and dress, thus giving time to ascend even from a very great depth. The connecting joints are now so manufactured that they can scarcely be broken, as they will resist the most powerful pressure, in consequence of having a double safety cap affixed.

The new vulcanised band completely excludes the water from the dress, and enables it to fit more easily and with greater comfort to the wearer. The signal dial makes the wants of the diver known to those above instantly and correctly, and, in fact, renders the apparatus nearly complete for the most difficult undertakings.

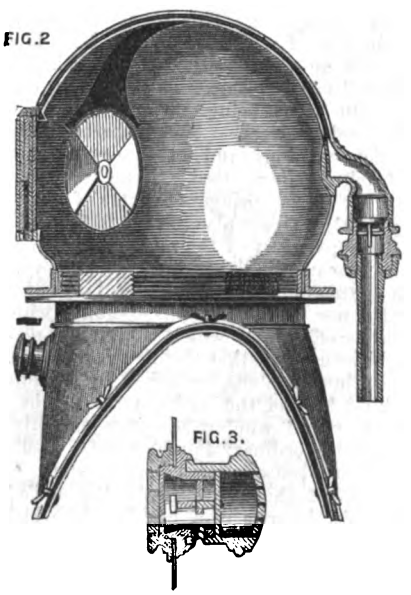
The illustrations show a section and elevation of one of Heinke's helmets, and a sectional view of the valve. Fig. 1 shows a front elevation of the helmet itself. It will be seen from this that the openings are also provided (as an extra safeguard) with segmental plates, so that by turning either disc round by means of the buttons which project from the circumference, the openings can be closed instantaneously. The regulating or safety-valve is seen in front of the helmet, just below the joint indicated by the letter A, which joint enables the whole top of the helmet to be taken off at pleasure. Fig. 2 shows a section through the head-piece, exhibiting the pipe at the back through which the air is fed down the valve for safety in the event of the bursting of a feed-pipe. From the orifice will be seen the tubes, extending over the upper internal surface of the helmet, for leading the stream of air over the glasses; and again below, and marked by the letter B, will be seen the safety-valve before mentioned, which can be opened or shut at pleasure by the diver. This valve is shown in section on a larger scale in Fig. 3. It will there be seen that an ordinary valve, which is held in place upon its seat by means of a spiral spring, is covered with a cap perforated on the top, so as to allow of the escape of such air as passes, but so fitted as to turn on the outside of the valve-box or seat at pleasure; this is provided with a long slotted hole, which runs

FIG. I.



some distance around its circumference, and the lower part of the valve-seat or box is provided with a similar slot. From this description it will be apparent that the cap can be turned so as either to let the two holes be in one, and thus open to allow of the escape of the air, or be closed should it be desired; by this simple contrivance the diver can regulate the egress of the air, and so the extent of the supply, to the greatest nicety. Figs. 4 and 5 show a side elevation and longitudinal section of the lamp, which it will be noticed possesses the following peculiarities and advantages. The amount of air which is supplied through the

FIG.2

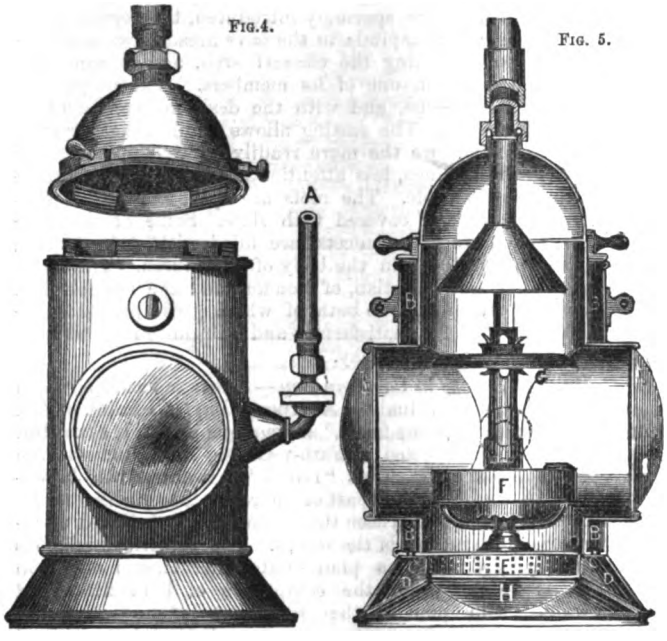


pipe A, Fig. 4, can be regulated by means of the tap; the air thus admitted flows into the external ring or case, which is shown by the letters BB in the sectional elevation, Fig. 5; it then finds its way through the perforated plate CC, at the bottom of the ring, into the receptacle DD, and thence through the strainer E into the lamp itself, for the support of combustion. The burner itself is of the form commonly called Argand, and supplied with oil or gas from the ring F, which is made open, so as to allow of the

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light from the lamp being thrown down from the reflector G, through the lens H, so that by this means the bottom surface of the sea can be examined without removing the lamp from its upright position. The lamp is also provided with two side-lenses I I; or three can be used if required. The upper cap is fitted with an internal cone, which is connected with a pipe leading to the surface of the water, for the escape of the products of combustion. This lamp gives a brilliant light, and the air supplied percolating through the lower ring enables it to burn steadily, a matter of considerable importance in such cases.

In 1855 a number of interesting trials took place with this apparatus in various places. The experiments which were conducted at Portsmouth in the month of June, in the presence of the Admiral-Superintendent and dockyard officers, gave great satisfaction; the diver remaining below half an hour at a time, in



a depth of 3½ fathoms. At Chatham dockyard, in October, a similar trial took place in the presence of the Captain-Superintendent and several gentlemen connected with the establishment, as well as many officers of the corps of Royal Engineers and others, who all expressed their gratification at the result of the experiment.

At Paris it was tested on the Seine, by command of the French government, and in the presence of Prince Napoleon, a large number of military and other engineers, the Commissioner-in-Chief, the Secretary of the Exhibition, and the members of the International Jury. On that occasion five kinds of diving dresses were tried (of which three were English and two were French), in every variety of situation. The apparatus which was attended with the most successful results, and which it was decided possessed the greatest facilities, was that exhibited by Messrs. Heinke. The diver, without any assistance, raised himself to the surface by partly closing the valve in the breast-plate of the helmet; the compressed air thus filled the water-proof dress and brought him up. When he wished to descend he had only to turn on the air valve.

In order to test the alertness of the divers twelve small rings were thrown into the river; of these Messrs. Heinke's diver picked up ten, and the other two were not found by any of the divers. Again, at the request of Prince Napoleon, he went down with a helmet the glass of which had been accidentally broken at the Westminster Bridge works, and which of course admitted water; he immediately closed the safety valve as directed, and remained under water half-an-hour before coming to the surface. The under-clothing was then examined, and was found to be perfectly dry. The divers representing the other makers were then requested to submit their apparatus to the same test, but they all declined. The French exhibitor, M. Ernoux, acknowledged the superiority of Messrs. Heinke's apparatus.

The lamp has been extensively used at Westminster-bridge. The water there being thick, the diver could only see for a distance of 18 inches or 2 feet, but it enabled the engineer to examine the granite, and to see if the divers had done their work in a proper manner. At Dover, the water not being so thick, but of a light milky hue, caused by the admixture of chalk, the diver could see 9 or 10 feet around. With this apparatus a diver could lay eight large blocks of stone, each weighing about 7 tons, in four hours. It has been in use at the new Westminster-bridge works for four years and a half, and all the under-water work has been done by its means, without a single accident.

The English government were so satisfied of the superiority of Heinke's apparatus to any others, that last year they retained the inventor's services to instruct the officers and men of the Royal Engineers in its use. An interesting experiment has just been commenced; it is an attempt at the recovery of a large amount of specie, supposed to be nearly £2,000,000, which was lost in 1822 by the foundering of the frigate Lutine off Terschelling. During the past thirty or forty years various attempts have been made to recover the treasure, and about £50,000 had, at considerable expense, been recovered; but the wreck ultimately sanded up, and she was entirely lost, until accidentally discovered in 1857, through a buoy which was carried away by the ice becoming entangled with the rigging of the Lutine. In this way it was discovered by some Terschelling fishermen, who got with great trouble the mass on shore. On being examined it was found that the tackle of the buoy had brought with it a portion of the wreck of the Lutine. The current here runs upwards of eight knots per hour, and it is with great difficulty that a diver can remain under water more than fifty or sixty minutes.

During the last fortnight the whole of the specie—about £280,000—has been recovered by the use ef Heinke's apparatus, by the Peninsular and Oriental Steam Navigation Company, from their steamship Malabar, lately wrecked.

EXHIBITION OF PRACTICAL WORKS, MATERIALS AND INVENTIONS CONNECTED WITH ARCHITECTURE, CONDUIT-STREET.

The promised free exhibition of building materials, patent inventions, and manufactures has been recently opened in the rooms of the Architectural Union Company, Conduit-street. Although the collection is by no means so extensive as could have been wished, it contains an interesting display of useful inventions connected with constructive art. Works in stained glass, marble, and wood are very scarce, if we except the beautiful examples in parquetry flooring forwarded by the London Parquetry Company, which for novelty of design and beauty of material and workmanship merit great praise. Messrs. Arrowsmith are also exhibitors of parquetry. Several improved arrangements of water-closets, drain-pipes, &c. may be noticed, exhibited by Mr. G. Jennings, Mr. Doulton, and Botten and Son. There are examples of mosaic pavement by Messrs. Maw and Co., and Minton and Hollins;—scagliola pillars by Messrs. Bellman and Joy;—patent locks by Messrs. Hobbs and Co.;—admirable imitations of marbles and woods by Mr. Kershaw;—stoves by Mr. Pierce and Mr. Boyd;—ecclesiastical furniture and metal-work by Messrs. Cox and Son, Hart and Son, and Johnston Brothers;—moulded bricks by Fayle and Co.;—with numerous miscellaneous articles, and a large and admirable display of models of cornices, figures, pilasters, capitals, and enrichments in carton pierre, by Messrs. Jackson and Son, and Messrs. White and Parlby;—we noticed also some large specimens in ornamental modelling in the Eastern Gallery by Mr. Desachy, worked in his recently patented material called "*Le staff*." These have been executed from the designs of Mr. Owen Jones and Mr. Edward Barry, architects.

The collection in the rooms is not yet completed; but when it is so we shall return to the subject.

Proposed New Street from Coventry Street.—A plan is under consideration for a new street commencing from Coventry-street, passing south of Leicester-square and in a south-east direction, and continuing along Orange-street at the back of the National Gallery, and in a line with King William-street. The plan has the support of the parishes of St. James and St. Martin, and funds to carry it out are in hand.

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STRAIN OF AN ELASTIC HOLLOW CYLINDER.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

In your review of Mr. Longridge's work on the Construction of Artillery (*C. E. & A. Journal*, August 1860, page 247), reference is made to the state of strain of the particles of a hollow cylinder pressed from within, in the following words:—"Of course the solution of the problem can be *exactly* effected by means of the partial differential equations for the internal equilibrium of a solid....."

For the integration of those equations in the particular case under consideration I may refer your readers to the standard work of M. Lamé, 'Leçons sur la Théorie Mathématique de l'Elasticité des Corps Solides,' § 80 (Paris, 1852). The process of integration, though somewhat complex in appearance, is simple in reality. The results are as follows:—

Let the internal radius of the cylinder be denoted by R;
the external radius by R′;
the distance of any intermediate particle from the axis by r;
the intensity of the pressure from within by P;
the intensity of the pressure from without by P′;
the intensity of the radial pressure at the intermediate particle by p;
the circumferential tension at the inner surface of the cylinder by T (this is the greatest tension);
the circumferential tension at the outer surface by T′;
the circumferential tension at the intermediate particle by t.

Then,

$$t = \frac{R^2P - R'^2P'}{R'^2-R^2} + \frac{R^2R'^2(P-P')}{r^2(R'^2-R^2)}$$

$$p = -\frac{R^2P-R'^2P'}{R'^2-R^2} + \frac{R^2R'^2(P-P')}{r^2(R'^2-R^2)}$$

$$T = \frac{R^2P-R'^2P'+R'^2(P-P')}{R'^2-R^2}$$

$$T' = \frac{R^2P-R'^2P'+R^2(P-P')}{R'^2-R^2}$$

When the pressure from without is insensible, the above equations become simplified as follows:—

$$t = \frac{R^2P}{R'^2-R^2}\cdot\left(1+\frac{R'^2}{r^2}\right)$$

$$p = \frac{R^2P}{R'^2-R^2}\cdot\left(\frac{R'^2}{r^2}-1\right)$$

$$T = P\cdot\frac{R'^2+R^2}{R'^2-R^2} \qquad T' = P\cdot\frac{2R^2}{R'^2-R^2}$$

I have demonstrated the same formula, by a method somewhat simpler in detail than that of M. Lamé, in 'A Manual of Applied Mechanics,' (1858), page 290.

W. J. Macquorn Rankine.

Glasgow, 2nd August, 1860.

Obituary.—On the 24th ult., in his 81st year, Mr. Jesse Hartley, the engineer of the Liverpool Docks, at his house, Derby-road, Bootle. In the death of Mr. Hartley the Liverpool public has lost one of its most distinguished men. He was a native of the North Riding of Yorkshire, in which district of that county his father held the position of bridge-master. He succeeded his father as bridge-master in the district named, until his removal to Liverpool, on receiving the appointment of engineer to the Dock Committee. As a dock engineer Mr. Jesse Hartley is admitted to have occupied a very high position. Possessing great natural sagacity, and imbued with an innate perception of the leading features of constructive design, he speedily acquired a profound as well as extensive knowledge of the requirements of that branch of science to which he devoted himself, and in the design and construction of the numerous docks of Liverpool he has left monuments of his skill as an engineer which will endure as long at least as the fame and commercial prosperity of the port. During the long period in which he held the office of dock engineer in Liverpool, Mr. Hartley altered or entirely constructed every dock belonging to the town. Besides these, he was employed as engineer for the Bolton and Manchester railway and canal, and he was also consulting engineer for the Dee-bridge at Chester. On all subjects connected with the construction of docks his opinion was considered by his professional brethren as high authority.

Peterborough.—In the suburbs of this city, the population having greatly increased, the need has long been felt of additional church accommodation. To meet this want a new church was erected, and completed within the last year or two; and on the 7th of last month a second was consecrated, dedicated to St. Mary. It consists of nave and south aisle, with a porch, and a chancel terminating in a semicircular apse. There is no tower at present (the bell being temporarily raised on the ridge of the porch), but it is proposed to place it at the west end of the future north aisle. The church is 98 ft. 6 in. long, by 37 ft. 6 in. wide, internally, and will accommodate about 500 persons, the outlay for the whole being about £2000. The site, which is a convenient and commanding one, was given by the Hon. George Fitzwilliam. The external walling is of Stibbington stone with Ancaster dressings; while internally white brick, relieved in the pier arches and a few other parts by red brick, is the prevailing material. Carving and colour are sparingly introduced, the former being confined to some bold capitals to the nave arcade, two elaborate foliage corbels supporting the chancel arch, and a handsome running enrichment in one of its members. The pulpit and font are of Bath stone, and with the desk are consistent in character and design. The seating allows ample space for comfort, a circumstance we the more readily notice, since in many so-called cheap buildings, less attention is paid to these arrangements than is desirable. The roofs are open, simply but substantially framed, and covered with slate. Some of the apse windows, which are plain lancets, are filled with stained glass, as is also one of those in the body of the church. The architect was Mr. Ewan Christian, of London, and the builder, Mr. Ruddle, of Peterborough, to both of whom great praise is due for having produced so satisfactory and substantial a structure at a comparatively small outlay.

Harbour of Refuge in Cardigan Bay.—A survey has lately been made by private individuals of Aberporth Bay, in Cardigan Bay. What are termed "lotus floats," and a stone pier or breakwater, is proposed to be erected at Fath-y-Garreg Point, to cover the harbour of Aberporth. That "refuge" is wanted will be admitted by all who know this part of the coast, the principal drawback to it having hitherto been the enormous cost believed necessary for the construction of the works. The gentleman who has munificently got up this plan states that not more than £40,000 is necessary for the completion of both floats and breakwater. The plan of the stone pier is one which has been successfully used in some of the small French ports, and there are one or two modifications of it to be found in Britain. The pier is simply a framework, divided at intervals of three feet into compartments, to be filled in with loose stones of all sizes, mingled together and well rammed down, but without any mortar or grouting. The outer covering or planking to be of 4-inch elm, placed at three inches apart. Round the outer extremity, and for some distance inwards on each side, vertical timbers are proposed to be added outside as fenders. It is proposed to start the lines of floats from Cribach Head in a north-easterly direction for three-quarters of a mile, then making a bend to the south-east—the total length being one mile and three furlongs—with the idea of covering the stone pier aforesaid. These floats it is proposed to make 25 feet long, conical in shape, of larch wood, divided into compartments by headings, well hooped with iron boiled in pitch, and each weighted at its lower extremity so as to float at high-water spring-tides, just at the level of the water. There would be three rows of floats, those in each line or row to touch each other at the surface. At low-water the floats would rise higher out of the water, by the value of the weight of three fathoms of the anchoring chain. These three rows would be attached to a main cable, securely anchored at short distances in the clayey bottom of the bay, and firmly fastened in the rock of Cribach Head. The mooring anchors proposed to be used are those known as Martin's. The originator of the present proposal is Mr. E. C. L. Fitzwilliam, the proprietor of the greater portion of the little town of Aberporth, on whose estate reside many widows of the poor sailors thrown away upon the coast at their feet. He is about to memorialise the Admiralty. He says—"The cost of the projected floating breakwater alone would not, if properly contracted for, exceed £28,000; but if it were £30,000 it would be a mere nothing for so valuable a safeguard for the lives of British seamen, as the largest ships in the mercantile marine in passing up to Liverpool could lie there in perfect safety."

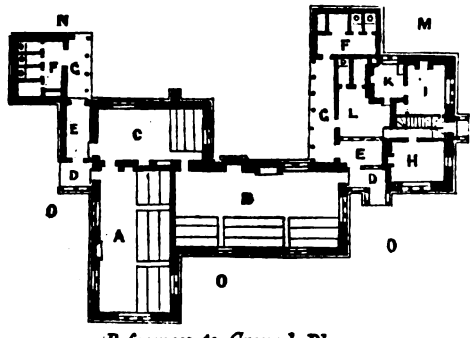
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HENHAM AND WANGFORD SCHOOLS, SUFFOLK.

(With an Engraving.)

THESE schools, of which we give a perspective view, occupy an elevated site on the eastern side of the road leading from Blythborough to Wangford, Suffolk; the park at Henham being on the western side. They have just been completed, and consist of a boys' and girls' school of nearly equal dimensions; a smaller school for infants, and a teachers' house with an entrance porch; hat and cloak room to each school, and the requisite offices. In style they are an adaptation of the French Gothic. The material employed for the walling is round stone, banded and quoined with red and white brick. The roofs are of tile, with bandings of white ornamental tile. The ridge is crested in red tile, and a timber spirelet or belfry turret rises from the main line of the same. The upper portion or gabled coverings of the windows are in timber, and terminate in ornamental finials in lead and iron, as do all the other apices of the roof, both gabled and hipped. The porches and the hat and cloak rooms are timber framed, and there is a timber penthouse over the entrance to the residence. The roofs internally are open timbered, and ventilation is obtained by perforations in the roof and by the circular eyelets shown in the timbered gable-heads of the windows. All the timber-work, both externally and internally, is covered or coated with pine varnish, slightly darkened with Stockholm tar. The back ground is appropriated to play-grounds; the front, to the approaches and plantation. The site was the gift of the Earl of Stradbroke; the Countess of Stradbroke was also a liberal donor: a government grant and local subscriptions making up the amount required.

The schools were erected from the designs and under the superintendence of Mr. E. L. Blackburne, architect, of Grenville-street, London. Mr. Mortimer, of Wenhaston, Suffolk, was the contractor for the works, at somewhat under £1000; Mr. Croft, of Wangford, performing for him the carpenter's portion of the same; Mr. Keable, of Henham, acting as clerk of the works.



References to Ground Plan.

A. Girls' schools.
B. Boys' school.
C. Infant school, used also as a class-room.
D, D. Porches.
E, E. Hat and cloak rooms.
F, F. Closets.
G, G. Covered ways to ditto.
H. Parlour—teacher's house.
I. Living room.
K. Scullery.
L. Yard.
M. Boys' playground.
N. Girls' and infants' ditto.
O, O, O. Approaches and plantation.

THE EXHIBITION OF BUILDING MATERIALS, MANUFACTURES, &c., CONDUIT STREET.

WITH the close of the architectural picture season at these galleries recommences that of the more practical character, the exhibition of building materials, models, patents, &c., the opening of which we just announced in our last number, and upon which we shall now offer a few comments. It may be premised that this is an institution which has been associated comparatively recently with its elder sister, but one calculated to be of essential service in furthering the interests of the able and ingenious tradesman, nor will prove less instructive to the man of science and education generally. There is much yet to be done before these objects are placed on a worthy footing. First, the manufacturer must see the advantage of this medium of making known his articles; and next, the seeker after such articles must know that they are here deposited, not in single samples but in a competitive range, so that while one party is stimulated to his utmost in perfecting the quality and attractiveness of his goods, the other will find it worth his while to investigate for himself into their intrinsic recommendations, and thereby have that opportunity of bonâ fide comparison which in the ordinary course of business is wholly unattainable. To insure this is manifestly advantageous to the skilful practical adventurer in art, and we should be glad to see more of that class among the exhibitors this year. As it is, those who have inspected the displays on the two previous years will have become acquainted with the names and productions of the majority of those that are now submitted to their notice. Not that we complain of this; on the contrary, it betokens on behalf of such parties a satisfaction as regards the past, but this should surely incite others to follow their example; had this occurred there would be no occasion to regret (as now) that the three galleries occupied are by no means overfilled, while the first room which the visitor enters is, unfortunately, entirely empty.

It is with cordial good wishes for the improving success of this undertaking that we venture on these remarks, and have yet one or two to add. There ought unquestionably to be a catalogue, as descriptive and detailed as possible, and if illustrated, so much the more acceptable. Some exhibitors have diagrams and woodcuts for their handbills already prepared, which would be quite available, and which they would doubtless be glad to introduce among others in a form which would thus be of sufficient value to preserve for reference, independent of its primary object; then again, in every case, information as to prices, net and wholesale, arrangements and cost of carriage (if any), the names of duly authorised agents, and references as to works actually executed, should be liberally afforded. But how are these requirements met in the present state of things? Will it be believed that there is no catalogue at all, in any shape whatever? Failing this, one has to resort to other expedients for gaining information, the most natural being to scrutinise for labels on the objects themselves; this is in most cases so far successful. But this is not always so, and then questions must remain unsolved, unless the inquirer bethink himself of applying to the curator in attendance, to whose courtesy in such a dilemma we have been more than once indebted, and who, it is but just to say, is ever ready to give the fullest information in his power. But, as it sometimes happens that he has not been primed for the occasion, there is no alternative but to put up with the disappointment. This want of a catalogue—it was so also last year—appears an inexplicable error on the part of the management; the want of "particularising," a scarcely less short-sighted policy on the part of the exhibitors. The idea of the latter may be to lead parties to apply at headquarters, and thereby pave the way to direct business transactions; but it seems equally probable that the reverse may take place, and that people who, if they could be made acquainted with all they naturally wish to ascertain, would have opportunities as well as the disposition to patronise meritorious works, now retire, to pursue the old beaten track; and thus the primary object of the exhibition sustains a check, instead of receiving a stimulus. It is not yet too late to remedy these matters; and since we have reason to know that we are not singular in our opinions, we shall hope ere long to witness a speedy improvement.

It has been stated that several of the largest exhibitors have retained their show-space from season to season, exchanging or varying the articles exhibited as seems desirable. Among such parties may be recognised Messrs. Minton, Maw, Desachy, Doulton, Jennings, Botten, Fayle and Co., Hart and Son, Johnston Brothers, Ransome, Cox and Co., &c. Having on previous occasions dwelt at length on the various productions of these well-known firms, it will be unnecessary to say more here than that in the present collection each is worthily represented. We have before alluded to Messrs. Williams, Cooper and Co.'s paper-hangings, as being unusually good of their kind; we can now refer approvingly to those also of Messrs. Harland and Fisher, of Southampton-street, Strand, who exhibit some meritorious Gothic designs, albeit some look rather too much like tile-paving arrangements. Messrs. Arrowsmith's parquetry is now well known, and the mode of its construction can be readily appreciated from the specimens contributed for the purpose in the rooms. It will be seen that it is solid, and not a mere veneer. Messrs. Jackson & Sons, and White & Parlby, again rival each other in the purity and elegance of their composition enrichments for internal decoration. The show of the latter firm is of the

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them to a low red heat in a small furnace termed the enamelling kiln. Glazed tiles are principally employed for Bath linings, and the sides and backs of fireplaces; also for pavements in combination with unglazed tiles, with which they form a very pleasing contrast.

THE LATE JOSEPH LOCKE, C.E., M.P.

It is with the greatest regret that we have to record another sudden and most serious loss to the engineering profession, in the death of Mr. Joseph Locke, which occurred at Moffat, on the 18th ult., in his 55th year. He was a native of Attercliffe, near Sheffield, where he was born in 1805, and received his education at the grammar school of the neighbouring town of Barnsley. His education being completed, Mr. Locke was placed under George Stephenson, at Newcastle, being bound for a period of five years. In 1826, when his apprenticeship was drawing to a close, the railway between Manchester and Liverpool was begun —the first great work under the modern railway system, and of which his master was the chief engineer. Under Mr. Stephenson, Mr. Locke was engaged on the line from its commencement to its opening, towards the close of 1830. His services during this period "were especially valuable with reference to the selection of motive power," ending as they did in the full perception by all concerned of the superior advantage of the locomotive engine. The pamphlet, published in 1830, in the joint names of Stephenson and Locke, on the disputed point, settled the question, although rope traction here and there continued to be used for a few years longer.

Mr. Locke's next great work was superintending the line from Birmingham to Warrington, now so important a part of the London and North-Western system. The line was commenced in 1832-3. Stephenson was again engineer-in-chief, but on Mr. Locke devolved the personal charge of the work from its commencement. Besides certain improvements in the rails and their fixing, one great merit in his construction of this line was its comparative cheapness, the cost not exceeding from £14,000 to £15,000 per mile. Besides the Lancaster and Preston, and other Lancashire lines, Mr. Locke undertook the engineering of the London and Southampton line, to which he devoted the major part of his time. The line was completed in 1840, since which date it has been extended by many branches. In the last-mentioned year he also undertook the construction of the Manchester and Sheffield line. Of Mr. Locke's subsequent railway works in this country, the most important was the construction of the system from the manufacturing districts of Lancashire to Edinburgh and Glasgow, the political and commercial capitals of Scotland. In this work he was united with Mr. Errington. Years before it was commenced Mr. Locke had sketched what he thought was the best course for the Caledonian line to take. Having to penetrate the rockiest part of the south of Scotland, the undertaking presented many difficulties, which it is admitted Mr. Locke overcame as satisfactorily as it was possible to do. On this line also, with its heavy works, he combined economy with excellence, the cost not averaging more than £16,000 a mile. There are heavy gradients on the line, but these have presented no particular difficulty to the locomotive in practical working. The Scottish Central, the Greenock, and other lines connected with and in continuation of the Caledonian, were all executed under the advice and superintendence of Messrs. Locke and Errington.

Mr. Locke has had a large share in the construction of the continental lines. Among the most noteworthy are the Paris and Rouen, the Rouen and Havre, Paris and Lyons, Caen and Cherbourg, several of the Spanish lines, the Dutch Rhenish, &c. In 1845 Mr. Locke received the decoration of the Legion of Honour from Louis Philippe: he was also a Fellow of the Royal Society, and M.P. for Honiton since 1847, having purchased the lordship of the manor of that place. He was but two years the junior of Robert Stephenson. He has survived Brunel exactly a year. It is remarkable that his death should follow so suddenly upon those of Stephenson and Brunel, to whose position it was allowed he was the heir, as the remaining chief of the engineering profession. The Civil Engineers had agreed in according priority to Locke, who succeeded Robert Stephenson as the President of the Institution, filling that office in 1858-9. This position was his due, as the chief representative of the Stephenson school.

MONUMENT TO THE LATE MAJOR HODSON, LICHFIELD CATHEDRAL.

(With an Engraving.)

The monument of which we gave an engraving in our last number is about to be erected in Lichfield Cathedral, to the memory of the late distinguished Major Hodson, of "Hodson's Horse," whose untimely death in the final assault upon Lucknow will be fresh in the memory of most of our readers. The work is to be executed by Mr. Earp, from the designs of Mr. George Edmund Street. The materials to be used are Caen stone, Mansfield stone, black limestone, alabaster, serpentine, and marble. The sculpture of figures and subjects is to be all executed in white alabaster. The central subject in the side represents the surrender of the King of Delhi to Major Hodson. The four figures at the angles are David, St. Paul, Arthur, and St. Alban—types of the Christian warrior in all times. The four quatrefoils (one at each end and two on the side) are to bear representations of four military virtues — Justice, Fortitude, Temperance, and Mercy. The cross and the coped top of the monument are to be entirely of serpentine.

The monument will stand under one of the arches on the south side of the choir, nearly opposite to the costly and elaborately sculptured monument to the memory of Archdeacon Hodson, the father of Major Hodson.

MR. SPURGEON'S NEW TABERNACLE.

The works at Mr. Spurgeon's new place of worship on the Surrey side of the river have progressed with great rapidity since the foundation-stone was laid. The building is now entirely roofed, and the interior is in a very forward state, the ground floor being laid, a portion of the walls lined with match-boarding, and the frame-work of the extensive galleries completed. Although the building of the towers which were introduced in the original design has been abandoned, the new edifice presents an imposing appearance. The walls of the chapel rest on dense concrete 3 ft. 9 in. in depth, the lower stratum being a stiff gravel, so that the foundations throughout are of the most unexceptionable character. The fine sextile portico at the eastern end is composed of columns having Corinthian capitals, with the usual entablature and pediment.

The tabernacle is, as we have before informed our readers, in the Classic style. No artificial material has been used, the whole of the exterior being of good stone. The plain surfaces of the walls are of Kentish-rag, and the entrance portico, together with the dressings of the doorways, windows, string-courses, and copings, of Box-hill Bath stone. The total length of the structure, measuring from the front steps of the chief entrance to the back wall at the west end, is 208 feet, and its width 106 feet. In addition to which width, externally, is to be added that of open areas at each side, in communication with the basement story. There is also an open area at the west end. The tabernacle, internally, including the vestries, all of which are planned on the ground-floor, is 174 feet long by 85 feet wide in the clear, exclusive of the portico. The internal height, from the basement level to the louvre light in the roof, is 89 feet. There are two tiers of spacious galleries entirely round the interior of the building, supported by a series of sixteen cast-iron columns, extending from the basement, standing firmly on brick pillars with concrete foundations.

Instead of the pulpit being placed near the wall at one end, as is generally the case, a tribune (if it may be so called), is projected from the western end, 29 feet long by 26 feet wide, and 4 feet high from the main floor line of the chapel. This tribune has a semicircular front on which the pulpit will be fixed, which arrangement it is expected will enable the whole of the congregation to both see and hear the preacher. With the idea of aiding the acoustic qualities of the edifice, no plaster work will be put on the walls, instead of which they are being entirely lined with wood. In the basement there is a large lecture-hall, together with a school-room and convenient class-rooms.

The works have been executed in a creditable manner by the contractor, Mr. W. Higgs, under the superintendence of the architect, Mr. W. W. Pocock. The building with its extensive galleries is arranged to accommodate from 9000 to 10,000 persons, all of whom, it is believed, will be able to see and hear the minister. It is expected that the chapel will be opened in two or three months from this time.

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with roof thereto, including a temporary roof to join the old and new work. The second portion consists of the new north aisle and vestry porch, and the substitution of new roof in place of the old one eastward of the round portion of the edifice; and the third comprises seating and fitting up of the church throughout.

The tender of Mr. W. M. Cooper, of Derby, being the lowest, was accepted, and ran as follows:—For section 1, £1937; for section 2, £1633; and for section 3, £1650 (subject to a reduction of £280 in case of pine being used for the sittings); making a total of £5220, or, with the reduction, £4940; and a contract was entered into for the execution of the first named section of the works, which were practically commenced in June. Local materials are being used as far as possible, the walling stone being procured from the neighbouring quarries at Duston. Coursed bands are to be occasionally introduced, and marble, to some extent, internally.

RESTORATION OF KILKHAMPTON CHURCH, CORNWALL.

This church, situate in a remote district in the upper corner of the county of Cornwall, on the high moorland road from Clovelly to Bude Haven, has obtained a degree of notoriety as having been the building which gave rise to Hervey's well-known 'Meditations among the Tombs.' The edifice, which was lately in a very dilapidated state, has now acquired a fresh interest from the extensive and substantial alterations which have taken place, a change mainly due to the liberality of the Rev. Lord John Thynne, sub-dean of Westminster, and whose son, the Rev. A. C. Thynne, is rector of the parish;—the parishioners assisting in the restoration of the nave. The exterior has been substantially restored, due regard being paid to the ancient south doorway, a fine example of Norman work. Considerable portions of the walls were rebuilt; the east end of the chancel and chapels entirely so, new windows being also placed therein; the roofs throughout have been entirely stripped, repaired, and covered with slate, the plastering when removed from the underside having brought to light a carved and bossed cradle-roof of oak. The whole of the pillars have been cleansed from accumulations of whitewash, &c., and the chancel entirely remodelled. In this part a cumbrous Classic altar-piece no longer obscures the east end, and the chancel and chapels are screened off by traceried and carved screens, that at the west end of the chancel being a low screen panelled. Entirely new oak seats have been placed in the chancel and chapels, the chancel and sacrarium being floored with Minton's tiles. The elaborately carved old seats of the nave have been carefully preserved and refixed on a new floor. The pulpit is new, richly carved in oak on a granite base; it is placed on the north side of the nave in front of the low chancel screen. A white metal lectern with brass ornaments has also been provided. The east windows of the chancel and chapels, and the side window of the latter, together with the west end window of the tower, have been filled with stained glass, from the designs of Messrs. Clayton and Bell: they are partly heraldic in character, and partly emblematic. The centre east window, of five lights, represents the Crucifixion and Sufferings of our Lord. The east window in the south chapel sets forth the Resurrection, while the two four-light windows on the south side of this chapel (which is the mortuary chapel of the Granvilles) represent the genealogical descent of that family from their Norman extraction to the extinction of the male line, and these have been contributed by various distinguished individuals "as a tribute to the memory of that ancient and loyal house from which they are respectively descended." In the corresponding chapel, Lady Carteret, widow of John, last Lord Carteret, has caused a window of like character to be placed, in memory of the descendants of John Granville, Earl of Bath, by whom the Kilkhampton property has been transmitted to its present possessor. Another window (four-light) contains figures of the four major prophets, and a three-light window commemorates the Birth, Presentation, and Baptism of our Lord. The window at the west end, seen through the lofty arch of the tower, is enriched with stained-glass by the rector and his wife, in memory of his brother, Captain W. F. Thynne, of the Rifle Brigade, who fell at Lucknow. The stone-work and roofs were restored and repaired by Messrs. Firks and Bone, of Liskeard; the fittings of the chancel, screens, and pulpit, by Messrs. Clarke, carvers, of Mells, near Frome, Somersetshire.

MAW'S MOSAIC AND ENCAUSTIC TILE WORKS, BENTHALL, SHROPSHIRE.

At the recent meeting of the British Archæological Association at Shrewsbury, the members visited the works of Messrs. Maw and Co. at Benthall, when Mr. George Maw explained the process of the manufacture. He said that it consists of two distinct branches, which are essentially different in nearly the whole of their processes. First, the making of encaustic tiles, or those inlaid with a pattern of two or more colours, which is the reproduction of an art limited in the mediæval times to church decoration, but now having a much more extended application. Secondly, the manufacture of plain tiles and tesseræ, of an uniform colour, used in the construction of geometrical mosaic pavements, similar in character to those found in the mediæval buildings of Italy; also moresque mosaics and tesselated mosaics, similar to those occurring in Pompeii and almost all Roman remains in this country and the Continent. The materials employed in both processes are nearly identical, and consist for the most part of the clays and marls of the Shropshire coal measures. These, without any colouring matter, together with clays from the south of England, form the red, buff, and fawn coloured tiles; and, in connection with different proportions of oxides of iron and manganese, the black, chocolate, and grey tiles. The white and all the richer-coloured tiles and tesseræ are formed of a species of porcelain, or parian, the white left uncoloured, and the blues and greens coloured with oxides of chrome and cobalt. The preparation of what is technically called the body of the tile, which is the first process in the order of manufacture, consists in mixing the constituent clays and other materials with water, and commingling and purifying by passing them in a semi-liquid state through a sieve made of the finest lawn, containing between 10,000 and 15,000 perforations to the square inch. All the coarse particles are by this means removed, and the texture of the clay rendered perfectly fine and even, as well as adding greatly to the brilliancy of the colour. The semi-liquid purified clay is then dried in what is termed the slip kilns,—if for the manufacture of encaustic or inlaid tiles in a plastic state, or for plain or self-coloured tiles, perfectly dry and hard. It is at this point that the two processes diverge, and are essentially different. There is also some slight difference in the proportions of the materials used in their composition, but this need not be more than noticed. The encaustic tiles are made of plastic clay, the pattern impressed from plaster of Paris moulds, and the indented surface filled in with different clays in a semi-liquid state. The tile is then allowed to gradually dry to the consistency of wax, and the inlain patterns developed by scraping off the superfluous clay. For the manufacture of the plain tiles, of one colour throughout, the material, which has been dried quite hard in the slip kiln, passes through a machine which grinds it to a fine powder, ready for moulding, which is performed in steel dies, under very powerful screw presses, some of which work at a power of thirty tons. Both kinds of tiles after having been formed, are placed for ten days or a fortnight in a drying stove, an apartment heated by flues up to 80 or 90 degrees, and when the whole of the moisture is driven out they are ready for burning. This is performed in large kilns, the tiles being stacked in fire-clay boxes, termed saggars; the actual burning occupies four days and nights, during which time they are gradually brought up to a white heat by the consumption of from 18 to 20 tons of coals, and during another four days and nights are as gradually cooled, occupying the kiln in a hot state eight days and nights. Great care is necessary in this part of the process to give the correct amount of heat throughout the kiln, as if the firing is not carried sufficiently far, the tiles are soft and irregular in colour, which necessitates a repetition of the process; and if carried beyond a certain point, they gradually decrease in size. They are judged of by certain tiles, (technically termed "proofs,") from time to time drawn out of the kiln during firing. The whole contents of the kiln may be spoiled in a very few minutes. The great bulk of the tiles are employed in the unglazed or biscuit state, the manufacture of which is completed with the burning. They have merely to be drawn from the kiln, and as they somewhat vary in size and colour, depending on the precise extent to which the fire has been carried on, they have to be passed through a gauge which divides all the larger forms into four distinct sizes. The process of glazing or enamelling is performed by applying a thin coat of paste, made of vitrifiable materials, on the tiles that have been previously burned, which is converted into a glass by subjecting

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most elaborate kind, and displays perfection and refinement of finish in a surprising degree. A fine specimen of wall diaper in relieved ornament is among their best specimens.

Fox's "Patent silvered glass" has received some new applications, and its lustrous effects are conspicuous in various ways. Hobbs's locks, and Tann's new "guarded" lock are always deserving of notice, as is Hart's door furniture generally. We miss this year Skidmore's metal work; specimens by Hardman, Potter, Keith, and others, are also wanting.

Messrs. Devaux exhibit a great variety of applications of zinc, as an ornamental as well as economical roofing material. It has been already described and illustrated in our pages. In Smith's "Ornamental woods" for internal decoration, the effect is apparently produced chiefly by burning: it is stated to be a durable and inexpensive process. Some imitations of marbles evidence the highest artistic ability. A series of large panels, by some exhibitor whose name we could not discover, are perfectly marvellous: they comprise imitations of Languedoc, Sienna, Rouge royal, Rouge vere, Pavonozetta, and Irish. Near them are also some capital imitations of the wood of the yew-tree, satinwood, cotton-tree, &c.

Among the novelties will be observed two hydraulic lifting jacks (patent), by Messrs. Daniel Adamson and Co., of Hyde, near Manchester, which appear to be no less effective than simple in construction. Pierce's stoves still assert their pre-eminence, and their qualities have now been tested by the public for many years. Edwards' "Patent chimney bar, and ventilating hearth-plate," is shown by diagrams and a full-sized model. In using the chimney bar (the contrivance of which is very simple) the flue is at once formed of the proper size. The effect of the contracted opening is greatly to improve the chimney draft, as the large open space usually left is unnecessary and objectionable. There is a register door which is opened or closed by means of a handle in the front. The hearth-plate is of cast-iron, and has a sliding ventilator. It communicates with the external air either between the flooring joists or by means of air bricks in the external walls. Boyd's fire-lump grates have the recommendations of being based on correct principles and being cheap. The back and two cheeks are entirely of this material, which is stamped into a somewhat architectural form, well suited to its purpose. In some of Boyd's fireplaces colour, as well as good architectural effect are attained by the introduction of pattern tiles in the sides and hearth. These tiles are prepared expressly for the purpose by Mr. Godwin, of Lugwardine, near Hereford, who has brought the manufacture generally to a high state of perfection. Boyd's "flue plates" are made in various sizes, and are intended to be built in walls, so as to form a hollow ventilating partition between two smoke flues.

In Elkin's "Patented improvements in window frames and sashes," shown in a model, the improvement consists in that portion of the frame called the pulley-style being made loose instead of fixed; it is kept in its place by an elastic arrangement at each end, and the face of the pulley-style is thus made to press equally against the edge of the sash. The removal of the sash is effected by pressing it sideways against the elastic pulley-style, which yields sufficiently to allow the sash to be disengaged from the beads of the opposite pulley-style. The free side is then drawn inwards, and the other side of the sash liberated from the elastic-style; the line is then simply unhooked, and the sash is disengaged. The pulley-styles may then be lifted out of the frame to repair weights or lines.

Several other models will be found to repay examination, but as they do not readily admit of description, we shall leave them, with the collection itself, for personal inspection.

ST. SEPULCHRE'S CHURCH, NORTHAMPTON.

THE most worthy motives for the restoration and enlargement of a church are those which appeal to our piety and charity; but a special interest of another kind will sometimes attach to a particular church, such as belongs to that of St. Sepulchre, Northampton, the repair and enlargement of which has just been commenced.

The great peculiarity of this church consists in its being one of the four round churches, and four only, remaining in England. Two of these churches were erected by the Templars and Hospitallers respectively; two religious orders, associated under the most solemn vows for the protection of pilgrims to Jerusalem. These were the Temple, in London, so called because it belonged to the Templars; and Little Maplestead, in Essex, which was attached to a Commandery of the Hospitallers. The other two churches can, however, boast of a higher antiquity, and are both dedicated to St. Sepulchre; the one being at Cambridge, and the other the building now under consideration. Of these, the church in Cambridge has, perhaps, the priority, having been consecrated in 1101; but that in Northampton followed immediately after, being assigned, with great probability, to Simon de St. Liz, Earl of Northampton, who died in 1115.

The condition in which he left the church of St. Sepulchre's may be inferred with tolerable certainty from several indications still remaining. It seems indubitable that it consisted of the present round, together with a chancel, terminating in an eastern apse. The principal entrance was most likely through a highly enriched doorway at the west end of the round, which has since given place to the present lofty tower and spire. Instead of a tower or other steeple to the original church, the round was crowned with a high clerestory or lantern, with a conical roof, also of high pitch; and, as there was a triforium over the aisles of the round, which has now disappeared, the whole elevation would not be deficient in height. The chancel, probably, had no aisles, being in that respect like Little Maplestead, and which it very possibly resembled too in its apsidal termination.

In the interior, the central circle of eight pillars and arches was surrounded with an aisle with a groined roof, over which was a triforium, opening into the church by a series of arches, probably little inferior in height to those below. Resting on them, and rising to some considerable height above them, was the clerestory or lantern, doubtless of eight lights, with appropriate decorations. A richly moulded arch would lead to the chancel, the details of which can now be supplied only from analogy. But though there is no reason to doubt that it was, both internally and externally, a structure of considerable elegance, it did not satisfy more than two or three generations in the state in which Simon de St. Liz left it, for, apparently about 1180, during the time of the gradual introduction of the pointed arch, but while the old Norman details were generally retained (thus forming a transition era) the northern wall of the chancel was cut through, to form an arcade, for the addition of a northern aisle. The work does not seem to have been judiciously or even carefully conducted, for the changes about this time originated in a series of failures in the fabric, which led first to the necessary erection of certain unsightly buttresses, and ultimately, perhaps, to the failure of the round and the sacrifice of the old triforium and clerestory. The twelfth century, however, probably closed upon a church scarcely differing from that which St. Liz had finished before 1115, excepting that a northern aisle had been added to the chancel.

There, so far as at present appears, the church remained for upwards of a century, for it is not till early in the 14th century that there are any indications of a southern chancel aisle. It was also before the close of the same century that the present tower and spire were erected. This was not without a purpose, for the round had probably suffered so much by former changes as to require great repairs. The aisle vaults, the triforium, were in all likelihood, sacrificed at this time, the clerestory being rebuilt on a more meagre scale, though certainly not so miserably as at present. A tower and spire were therefore required to give character to the church, and the one which has been raised is in every respect worthy of the county more especially noted for its beautiful steeples.

In dealing with such a building for the purposes of enlargement, it was by no means an easy task how best to accomplish it, without too much disturbing the various peculiarities which its ancient architecture presents. To interfere with the "round" was of course out of the question, consequently all that could be attempted must be eastward; and the additions, of which the first stone was laid with due ceremony on the 11th of September, comprise an extension of the parallelogram portion with its two aisles to serve as the church proper, and a still farther extension eastward of the centre portion serves as the new chancel, which will be terminated by an apse. These alterations are in accordance with drawings prepared by Mr. G. G. Scott, who has already restored the Norman church of St. Peter's, in the same town. The funds at present in hand not being sufficient to warrant the undertaking of the whole at once, the contract has been divided into three sections; the first comprising the structure of the proprosed enlargement (exclusive of vestry and new north aisle)

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ON GENOA.*

By T. Roger Smith, Architect.

The beautiful city of Genoa, distinguished among the other chief places of Italy by the proud title of *Genova la Superba*, and well worthy of the epithet, would furnish materials for a paper far more elaborate than the short series of observations which I am about to lay before you. To those who travel solely in search of examples of Gothic architecture, or who care for notes on foreign cities only when they convey information on this head, the name of Genoa would be unattractive; such persons probably, having satisfied themselves that beyond one very fine example, namely, the cathedral, Genoa contains few remarkable Gothic buildings, small or large,—while she abounds in examples of what Mr. Ruskin would call "pestilent," very pestilent, Rénaissance, and glories in them too,—would when they visit Italy bestow but a passing glance on this city. But to all others, to all those Gothicists who are catholic enough to admire and study Classic works, even if they do not execute them, to all who believe that an architect, if he select one exclusive style, should defer the selection till he has made himself master of as much that has already been done as possible; and above all, to those who contemplate either the partial or the exclusive practice of Italian architecture, Genoa is the most valuable city in Italy, save one.

From the peculiarity of her position, all travellers entering Italy for architectural purposes either by land or sea are pretty sure to reach Genoa early in their journey, unless they direct their steps to Venice. And there is nothing but a visit to Venice that would be a sufficient excuse for omitting or postponing a careful examination of Genoa; and even Venice, though undoubtedly richer in specimens of good architecture than any city in the world, must yield the palm to Genoa for a certain class of domestic buildings of the highest excellence, which are well suited to the study of English architects, being built to catch as much daylight as possible, to stand in narrow and crowded thoroughfares, and for a climate more similar to that of England than is found in most parts of Italy.

To those who in reading about Italian artists have had their attention drawn mostly to that galaxy of painters, sculptors and poets who lived in and about Rome and Florence in the fifteenth and sixteenth centuries, it may be interesting to learn that a name, so little known among these that possibly to some it may be almost a new name, is the one most associated with the architectural beauty of Genoa: I refer to Galeazzo Alessi. He was born in the year 1500, at Perugia, and was in early life a pupil of the well known Pietro Perugino, the first instructor of Raffaelle, and later was a friend of Michael Angelo. He lived here the greater part of his time, and not only executed most of the palaces and public works built during his life, but left behind him designs for others which were carried into execution after his death. His reputation is less than the great excellence of his works merits, and many will probably visit Genoa to whom the very high position to which Alessi is entitled among Italian architects will be as much an agreeable surprise as it was to myself. This sort of surprise however is happily a constantly recurring pleasure in Italian cities; many of the artists who flourished in them have left works which can from their nature never be removed, and which are not much known from engravings; and just as it is to most a surprise as well as a pleasure to find at Mantua how great a painter was Julio Romano, or at Milan how great was Luini, so is it an equally agreeable novelty to meet with the works of the Perugian architect here in Genoa. Lest no other so suitable opportunity should offer, I may add that in no other city is the graceful pencil of the pupil and assistant of Raffaelle, Pierino del Vaga, seen to so much advantage; and that the galleries of easel-pictures, several of which are very fine collections, contain examples of one or two artists of great power, but whose works are not much known elsewhere. This is especially the case with Bernadino Strozzi, known as Il Cappucino; and singularly enough with Mabuse, of whose work I have seen nothing to compare with one or two pictures at Genoa.

Having now just introduced the subject, it seems I think almost needful, before going further, to advert to the personal character which it is feared this paper may assume. I do not however apologise for it. This paper would never have been written had I not become somewhat familiar with Genoa from repeatedly visiting that city. The impressions that were made on my own mind, and the observations on Genoese architecture which there occurred to me, will have the likelihood of being at least more new than if I had resorted entirely to books; and though it will be my duty to lay before you many particulars gleaned from books to which all have access, yet it seems to me that the chief aim of a paper like this should be to endeavour to convey to you the impressions of an eye-witness,—to tell you what an English student of architecture found in Genoa that seemed to be worthy of study, and what influence was exercised on his mind by all that is to be seen there. So far as time and space permit, I shall refer to the kindred arts and any other subjects of interest that may present themselves, being convinced that to make such a tour too exclusively architectural is a great mistake. As a leading aim, the cultivation of general good taste and of a comprehensive knowledge of the fine arts, should, along with the study of our own art, never be lost sight of, nor should the opportunity of mixing freely with men of all classes and countries be neglected. An architect, to succeed, must know much besides what is architecture, and must be other things as well as an architect: nay, the very pleasure of such a tour should be carefully cherished. It is an opportunity of combining pleasant associations with your future practice;—associations that will last your life, and will make many a day's work more pleasant. It is not only mere gain of happiness that you thus make, but there is a practical gain of power, for all work done cheerfully is done well, and that which we love and labour upon with a will is that which will do us most credit. Beware then of allowing yourself to be annoyed at small worries, or wearied by a slavery of sight-seeing when you travel. Work honestly and hard, but make as much as ever you can of the deep varying interest of foreign travel,—the charm of climate, the beauty of language, and all the pleasure of novelty and variety.

In these preliminary observations it is only necessary that I should add the names of such books as will be of use. For travelling purposes Murray's Guides have deservedly obtained a high reputation, and the traveller will find in his account of Genoa a great portion of the information he may require: the facts are perhaps rather miscellaneous, but the statements are generally correct, and the view of the subject comprehensive. An excellent German guide-book to Italy exists, more compendious and complete and better arranged than Murray,—Förster's 'Italien': it contains much historical information, and many maps and plans of cities: a French translation of it is also published. In the 'Modern Traveller,' an excellent work published in 1831, and giving a compilation of the accounts of all the most trustworthy travellers up to that date, there is a good account of Genoa, and references are there given to many books that treat of this place. The history is to be found, mixed with the general history of the other states, in Sismondi's smaller and larger works. I am not able to name to you a good separate history of Genoa, but I believe one exists in Italian, if not in English. For architectural purposes there exists an old work, said to be by Rubens, neither accurate nor well got up; but there is also a beautiful French folio, in two volumes, 'Les Plus Beaux Edifices de la Ville de Gènes,' by Gauthier, in which the examples are well chosen and correctly given. This is a valuable work, and worth possessing.

We will now proceed with our main subject. I have entered Genoa both by land and by sea. The road from Pisa—the Cornice—is perhaps as beautiful a coast-road as exists in Europe, and the continuation of that road between Genoa and Nice, though less beautiful, is very famous. But as regards the city itself, the finest general view is from the water; and the traveller should contrive to arrive by sea—leaving, if he go eastward, by the coast-road. If he arrive by the coast-road or the railway he should not fail to take a boat on the harbour, for the sake of seeing the prospect of the town from there.

The view of Genoa from the sea has been often described by travellers while on the spot, and with the vividness of the impression still fresh on their minds: so that it will be better appreciated from consulting their written accounts than from anything I may be able to give you at this distance of place and time. Two piers protecting the entrance to the harbour run out into the sea from opposite ends of the little bay; and where the easternmost of them joins the land there rises a very picturesque and lofty lighthouse. A long and tolerably regular sweep curves from one pier to the other, and forms the land side of the harbour, lined

* Paper read before the Architectural Association.

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the greater part of the way by steep stone facing to the banks. The city, which has somewhat the general form of a crescent, lies behind the banks of the harbour, a broad space being reserved for quays. The sweep of the harbour banks and of the city hardly shows so well from the water as from some of the heights behind the city. You become aware of it however when, as you get inside the mole, you lift your eyes above the web of masts and cordage, and see the roofs piled one above another rising abruptly up the steep hills which shelve down to form the harbour; while beyond them again you catch the distant line of loftier heights along which runs the great outer circuit of fortifications, nearly twenty miles in length. The view of the old and lofty mansions which stand close upon the harbour must always have been obstructed by the shipping, but it is now a good deal shut out by a high wall of white marble, which incloses the quays, and on the top of which there is a splendid promenade; but above this are seen the houses and roofs rising thickly, picturesque in their variety of shape and size, their close proximity, and the many colours with which they are painted. Here and there rises a tower or a cupola, and the background of hills that encircles the whole is in summer brilliant with the blended tints of wild flowers, especially the gay oleander. Above you is the clear blue Italian sky, and below you the lapping waters of the Mediterranean, no less blue nor less clear, nor, as you half fancy, less deep than the sky above.

While we are waiting to go ashore, we may perhaps for a moment turn to one or two topics historical and general that ought to find a place in an account of Genoa, but which if put further on might interrupt rather than explain our observations. The history of the place seems to have been influenced to some extent by its geographical situation. Built on the sloping rocky declivities of a sort of natural basin or amphitheatre, whose sides run down into the sea and form her fine harbour, Genoa seems to rest on the ocean from which she has won her wealth and activity. The lofty mountains behind which seem to shut her in, really do so; and any person casting an eye over the map of Italy will observe that Genoa is more isolated on the land side than any Italian capital except Venice. The Ligurian alps approach here so close to the shore as to cut off Genoa to a great extent from such molestation by land as was peculiarly easy in the case of cities placed either in the great Lombard plain or in the southern one that stretches from Florence to Naples. Accordingly, in the great tangled web of embroilment which the active part of the history of modern Italy presents, Genoa, influential though she was, is often absent for a long period from the scene, as long as maritime warfare or internal dissensions are not the topic. But she was none the less a sharer in the turbulent spirit of the times, and as the great highway of the seas was the one which she traversed most, she aspired to vanquish there those other maritime Italian states who were her chief rivals in commerce. In the short historical sketch which I am about to give you, abridged partly from Dr. Förster, but with some additional statements for which Sismondi's shorter history is my authority, the wars of Genoa with Pisa and with Venice form the most conspicuous feature; and I can bear personal testimony that to this day the sense of national triumph connected with their greatest victory over the Pisans remains not altogether lost among the people. I was gazing at some huge fragments of the celebrated chain which had formed part of the barrier of protection to the Pisan harbour, and which still hang as trophies at one of the old city gates of Genoa, when a working man came up to me, and told in his harsh Genoese Italian (much of which I could barely comprehend) the story of the fight, the victory, and the trophy; and his eyes glistened as he spoke with genuine national pride.

The earliest historical mention of Genoa is in Livy, who says that Mago, a brother of Hannibal, attacked the city by sea and destroyed it. Rebuilt by Spurius Lucretius, it remained under Roman rule till the fall of the empire, when the province of Liguria, of which Genoa was the chief town, fell into the hands of the Lombards. It was only under Charlemagne and his son Pepin that Genoa began to revive: the latter prince gave her to a certain Duke Ademar, under whom she conquered Corsica in 801. Although conquered, destroyed, and depopulated by the Moors in the tenth century, Genoa yet revived, and again grew to be the principal city of the Ligurian territory, and in alliance with Pisa expelled the Saracens from Sardinia in 1022. She subsequently erected herself into a free republic, and gained great distinction at sea, taking part (in 1101) in the Crusade under Baldwin. She conquered Ceffa in the Crimea, and several Greek islands; and in fact her power increased in the East to such an extent, that some of the Greek emperors were glad to purchase peace by payment of tribute. It will be fresh in the memory of many of you that our troops engaged in the late Crimean war came on various occasions in sight of ruined Genoese castles, reminding us of this occupation: I think one of them crowned the heights above Balaclava harbour.

The great contest which divided Italy into the two factions of Guelphs and Ghibellines was warmly taken up at Genoa: the chiefs of the Guelphs were the Doria and Spinola families, of the Ghibellines the Grimaldi and Fieschi. In 1190 they adopted the expedient, not unusual among Italian states in those disturbed times, of electing a dictator, who was termed "Podesta," and who, in order that he might be able impartially to curb the violence of faction, was always a foreign prince, as it was felt that all the great men of each state were invariably committed to one or other party in the strife. At this time a constant struggle with Pisa and with Venice was being carried on, for the most part occasioned by rivalry touching the possessions they each held in the East; but between Genoa and Pisa a further cause of ill blood had always remained, arising out of their joint conquest of the island of Sardinia two centuries before, the fruits of which it appears Genoa had managed to appropriate to herself alone.

So long back as the time of the Crusades these three cities had more vessels on the sea than all the rest of the civilised world, and Genoa alone had risen to such a pitch, that in the zenith of her greatness she extended her power "over Sardinia, Majorca, Minorca, Malta, Crete, Lisbon, and Negropont, and had settlements in Scio, Smyrna, and several other cities of the Levant," and now came the contests which she hoped would rid her successively of her two powerful rivals. "It is difficult to comprehend," says Sismondi, when giving the history of Pisa, "how two simple cities could put to sea such prodigious fleets as those of Pisa and Genoa. In 1282, Ginicel Sismondi commanded thirty Pisan galleys, of which he lost half in a tempest, on the 9th of September; the following year, Rosso Sismondi commanded sixty-four; in 1284, Guido Jacia commanded twenty-four, and was vanquished. The Pisans had recourse the same year to a Venetian admiral, Alberto Morosini, to whom they intrusted one hundred and three galleys; but whatever efforts they made, the Genoese constantly opposed a superior fleet. This year, however, all the male population of the two republics seemed assembled on their vessels: they met on the 6th of August, 1284, once more before the Isle of Meloria, rendered famous forty-three years before by the victory of the Pisans over the same enemies. Valour was still the same, but fortune had changed sides; and a terrible disaster effaced the memory of an ancient victory. While the two fleets, almost equal in number, were engaged, a reinforcement of thirty Genoese galleys, driven impetuously by the wind, struck the Pisan fleet in flank; seven of their vessels were instantly sunk, twenty-eight taken. Five thousand citizens perished in the battle, and eleven thousand who were taken prisoners to Genoa preferred death in captivity, rather than their republic should ransom them by giving up Sardinia to the Genoese. This prodigious loss ruined the maritime power of Pisa; the same nautical knowledge, the same spirit of enterprise, were not transmitted to the next generation. All the fishermen of the coast quitted the Pisan galleys for those of Genoa. The vessels diminished in number with the means of manning them, and Pisa could no longer pretend to be more than the third maritime power in Italy." After this victory the Genoese had no rivals left at sea save the Venetians. Nine years later (1293) a naval warfare between these two powers broke out, which lasted seven years, ending in a great victory in the Adriatic Gulf of the Genoese over the Venetians.

The internal history of the fourteenth century here is one of constant political changes. In 1311 the Genoese, distracted by the feuds of their nobles, agreed to submit themselves for twenty years to the Emperor Henry VII. of Austria; subsequently, finding his yoke galling, they transferred themselves to the supremacy of King Robert of Naples. In 1339 they decided to be governed by a doge and a council, and elected Simon Boccanegra as their first doge; in 1396, annulling the dogeship, they gave themselves to Charles VI. of France, but thirteen years later made another change, and finally reverted again to the old form of government with a doge at the head. Meanwhile, in 1352 and 1354, naval contests had taken place of the greatest violence

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between the Genoese and the Venetians, in which the advantage remained with the former.

War broke out again in 1378, and after varying success the Genoese attacked and took Chiozza on the Lagune, and seemed to have Venice at their mercy. The decisive blow was however warded off; the Genoese fleet was besieged and defeated in its turn, and Venice, having passed through the greatest danger she had ever experienced, began after this crisis to gain the ascendency. Genoa, on the other hand, appears from this time to have been much weakened by her great internal troubles. She lost much of her commercial position through the taking of Constantinople by the Turks. After being for a short time subject to the king of France, then Henry VII., the Genoese in 1464 submitted themselves to Francesco Sforza, Duke of Milan; but in 1478 they revolted against his successor; in 1499 Louis XII. invaded Italy, and Genoa with other states passed into his possession. From this time Spaniards, Germans, French, and Swiss by turns fought for and oppressed the unhappy Italians,—and the most brilliant event in a dark chapter of history is the revolution at Genoa in 1528, by which the great Andrea Doria expelled the French, and restored to his compatriots a measure of liberty to which they had long been strangers, and which they maintained more or less intact for two centuries and longer. The republic stood out bravely, amid the failing wreck of Italian greatness, against the foreign oppressors; crippled though she was, not only by the loss of the commerce of the East generally, but by the new course which the discovery of America gave to the enterprise and research of Europe. In 1684, Genoa for refusing to subject herself to France, was bombarded by Louis XIV.; and in 1746 she was attacked by the Austrians, to whom she submitted; but the same year a popular insurrection expelled their army with great loss, and restored the independence of the state—one of the last brilliant events in Italian history.

Napoleon formed a Ligurian republic, of which Genoa was the chief place, in 1797. In 1800 Genoa was besieged by the Austrian troops and our own fleet; and Massena, who occupied the place, made a long and heroic but unsuccessful defence. In 1804 Napoleon united Genoa to his own dominions; and the congress of Vienna gave her to Sardinia, under which kingdom as you all know she still remains, tolerably prosperous, but not contented,—still longing for independent existence, still remembering the brilliant days of her republican greatness; and perhaps at times recollecting that the island of Sardinia was the earliest won and the longest held of her foreign possessions.

Genoa has been called the "City of Palaces," and as it is these which will chiefly occupy our attention, I propose to add to our historical notice one or two general observations upon their architecture. In most Italian cities all large houses are built with an internal courtyard, and in nearly all this courtyard is free to the public, just as the courtyard of Somerset House is with us, though in one or two cases at Genoa, and in the majority of houses at Naples, there is a porter at the gate, and promiscuous entrance is denied. It is not however ordinarily so: where there are picture galleries they are shown with great liberality and courtesy; and persons sketching in the *cortiles*, as these inner courts are called, are always quite free from molestation.

The most distinctive peculiarity of the Genoese palaces is their skilful arrangement of plan, especially with reference to what one may perhaps call internal exteriors. I mean by this phrase the exteriors of those parts of the building which look into the courtyard. The ordinary arrangements of a Genoese palace are much as follows:—The front rises directly from the street, as in nearly all genuine street architecture, without anything like a fore-court, or even a railing. It is usually very flat, that is to say, if breaks of the face occur at all, they are not often carried down to the plinth; and in the majority of instances there is no attempt to gain effect by breaking the sky-line; this however is by no means universal, and many graceful instances of such variety exist. The fronts are usually full of windows, and in that respect are most valuable to us, as we are in England ordinarily obliged to furnish such a large proportion of openings that we are shut out from the means of effect employed by the Florentine and Roman architects. Great regularity invariably exists in preserving the centres of openings vertically one above another, and in spacing the piers and windows. The openings are very frequently indeed arranged in alternate stories of long windows and square ones, and often a long window and the square one above it are combined together in treatment. The height of these façades is considerable, the number of stories being usually five or more. As in these particulars Genoese elevations approach to the dimensions and conditions of many English buildings, I will give you the particulars of a few palaces which I sketched and partially measured, premising that I do not vouch for precise accuracy as to dimensions: they are however, if not absolutely correct, within a few inches:—

Palazzo Brignole Sale—Frontage about 88 feet, height the same, divided into five stories, with seven windows on each floor.

Palazzo Cambiaso—Frontage 84 feet, height 95 feet; five stories, and seven openings in each.

Palazzo Plitardi—Frontage 78 feet, height 90 feet; seven openings, but six stories.

Palazzo Centurione—88 feet frontage by 85 feet high; again seven openings and six stories.

These I selected for drawing as being the best examples of the average run of the palaces in every respect—size as well as style. Of course, in counting the stories, many of them are mezzanine, and these sometimes are partly absorbed by the upper part of a room.

The palaces I have mentioned certainly agree closely. There are some with much more extensive frontages; for instance the palace of the king, formerly the Palazzo Marcello Durazzo, which has a frontage of over 300 feet; and the present Municipio, formerly Palazzo Tursi Doria, which occupies a still more extended frontage. In this latter instance—one of the best exteriors, as well as interiors, in Genoa—we have a central main building occupying 130 feet or thereabouts of frontage, flanked by two open wings of three arches each, sheltering promenades, while the basement is continued beyond these again to the full extent of the frontage, and has a garden on it. This palace is remarkable for its basement, in which the architect seems to have solved very happily the problem of how to make the parts which obtrude themselves on the eye of a spectator varied and interesting, without at the same time destroying their apparent solidity, and so unfitting them for the duty which their position requires them to seem fit to perform.

This arrangement of a cortile is one so opposed to our customs of building that I have found great difficulty in hitting upon any example in London even remotely resembling those of Genoa. Usually, when a building has an open space as part of it, we are in the custom of arranging this opening as a fore-court inclosed by either side walls or wings, and with a front screen-wall: Dover House, the Admiralty, the Horse Guards, and Burlington House, are examples of what I mean. Perhaps the nearest approach to such a cortile as occurs frequently at Genoa is the interior of the Royal Exchange; that at Somerset House is handsome, but too extended to approach to the concentrated richness of effect of the interiors in question.

It is not quite easy to understand why these internal effects have been so little sought after by our English architects. There is above all things this advantage in them over external ones, that you are to a great extent master of the points of view from which they shall be seen. Spectators of the exterior may if they like persist in standing just where you would prefer not to place them; neighbours may block up the very point of view which you had in your mind all the while you were composing the design; and, what is perhaps the most vexatious of all, some part of your building which you had left plain, or even ugly, in the belief that it would be quite hidden, thrusts itself obtrusively into notice, or is laid bare by the felling of trees or pulling down of houses. But when you take a spectator in at a gateway or up a flight of stairs, you have only to arrange your interior so that it shall look well from the top of the stairs or the inside of the gate, and you are quite sure of its being seen from that spot by every visitor; for there is no other way in, and every person who gets through any doorway or up any staircase for the first time invariably pauses and looks around; now this is an advantage, and you have the negative advantage also, that if your architecture will look ill from any spot, you have but to adopt one of fifty possible ways of rendering that spot inaccessible, and you are saved from the hostile criticism you might otherwise provoke.

That this power of placing the spectator where you will, and arranging the architecture for him to look at from certain points, has been understood and appreciated in the design and arrangement of the Genoese palaces, will be abundantly evident from the examination of only a few examples out of many that I might adduce; and the description that I shall offer you of the cortile of the Pa-

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lazzo Balbi Piovera is as good an instance as could be selected. If we have been slow in this country to imitate such examples, we must attribute the fact as much to our use of corridors as to any other circumstance. In Italian houses it is not considered objectionable for rooms to lead one out of another, and hence a depth of building sufficient to contain the rooms needed, placed one beyond another, will suffice. But we require a corridor, with separate doors to each room; and this corridor can be most conveniently obtained in the heart of a compact block. Yet I feel persuaded, that by judiciously employing the arcades of a cortile for corridors, filling them up with glass, we may combine the beauty of the Italian plans with our own especial notions as to comfort and convenience. We possibly require more light, that is to say more window-space, than even the Genoese, and on that account may have shrunk from introducing a feature which would, at least in unskilful hands, perhaps run the risk of seeming to appear dimly lighted. There can be no question however that a field lies open in this direction for a talented architect.

When the visitor proceeds to inspect the city, he will find the streets nearly all too narrow for any wheeled-carriage to pass, and as the traffic is very great, the bustle and noise in these narrow streets is not inconsiderable. Tortuous and perplexing as are these *vicoli*, something of a clue may be got to their arrangement by recollecting that two or three belts of streets of some length run parallel to the curved banks of the harbour, and these are tolerably level, while short, irregular, and hilly streets cross them at various points, and take a course converging towards the harbour.

We will suppose that the visitor goes up one of these—the Strada dei Orefici,—the street of goldsmiths. You find yourself in a bustle of men and women displaying the many varieties of dress and nation so often found at a great seaport. The dingy houses on each side the narrow way are evidently old; you come here and there to a sculptured representation of the story of St. George and the Dragon, and on inquiring the meaning of this effigy both here and in other parts, find that St. George was the patron saint of the goldsmiths, and that the goldsmiths were among the most influential of the tradesmen of Genoa, in fact their manufacture still is a famous article of commerce. Here you have, in open unglazed little shops, the most graceful articles of gold and silver filagree work, in the greatest profusion and variety; but perhaps to a visitor eager to get to the great streets these trinkets will be less attractive than at another time. I question however whether the greatest architectural enthusiast could pass the first lady he saw in real Genoese costume without stopping to admire one of the most graceful of all national dresses. They wear over their dress, which is always of a dark colour, and falling in sweeping folds, a long white scarf of muslin going over the head, shoulders, and arms, fastened to the hair by silver pins, and hanging from the arms in a way that is indescribably picturesque, and which it is said none but a native can hope to attain. These rather nun-like figures add amazingly to the quaint appearance of the narrow streets of old Genoa. After pursuing any one of these ascending alleys for some time you are landed in the range of new streets where stand the celebrated palaces,—wider indeed than the old, but still to our eyes very narrow for the display of such fine buildings.

The Strada Nuova, Strada Nuovissima, and Strada Balbi form a continuous series of streets of considerable length. They were, I believe, all cut at the public expense in the sixteenth century. The Strada Nuova has no other buildings in it than palaces of the greatest beauty, and on this account always used to recall to my mind our own Pall-mall; though it is right to observe that there are so many differences, that any person going to Genoa with Pall-mall in his mind, would be probably little able to detect the resemblance at first. Strada Nuovissima and Strada Balbi have the fine buildings more scattered, but are, none the less, noble streets; and the whole series comes I think next to the Grand Canal at Venice for effectiveness of anything in Italy. Probably however there will be a good deal of disappointment mingled with admiration. The narrowness of the streets is perhaps a drawback to the effect of the palaces, till you are familiar with them,—though I am not so sure of that as most people: there is a good deal in being able to tell where your spectator can *not* get to when you design; unquestionably however, the splendour of a first *coup d'œil* would be enhanced by greater width. Then there is such a fascination about the word 'marble," that a traveller fresh from London, or even from Paris, and who has been more accustomed to marble for chimney-pieces and statues than for anything else, will half expect to find the black kind as glossy as a raven, and the white rather purer than driven snow, while the whole front shall bear such a polish, that as he walks to and fro past it his image shall be reflected as in a mirror. It is needless to say, that to find that the effects of a very humid climate have made the white dim and the black dull, and drawn weather streaks and stains over the whole of a front which of course never was polished at all, must prove a shock to such expectations; though a few days teach you to love the weather-stains on marble as much as those on our own stone abbeys and churches.

The palaces are not all of marble however, and the visitor may be a little startled at the positive colour selected for painting those of them that are in cement. For instance, one very fine one, the Brignole Sale, is all over a bright brick-dust red; and the same colour has been selected for the most prominent church —the Carignani. Another palace is of a rather *prononcé* sage-green. I mention these things as casual matters, observed for a moment—soon forgotten. The grandeur and beauty, the skilful proportions, the rich composition, the precious material, and the noble, palatial character of these buildings, are never forgotten—in fact, never cease to grow upon you the longer you remain among them. Theirs is the true aristocracy of bearing—dignified and reserved rather than ostentatious to the outer world,—nay, perhaps somewhat chilling, at any rate grave, externally; but, when you have passed the threshold, receiving you with a lavish display of grace, ease, and beauty, of a far gentler and more winning kind.

The framework that I have endeavoured to describe in giving some account of the frontages of the palaces, is generally very richly covered. Alessi, whose manner was closely copied by those other architects who built at the same time, seems either to have had some dislike to the large masses of plain surface on which the architects of Rome and Florence relied so much for effect, or else more probably to have felt that he had not enough of it at command to produce effects as noble as he wanted. He accordingly was wise enough, having been brought to decide upon another course, to follow it up thoroughly; and in consequence has very much covered both the piers between his windows and the spaces below and above them with architectural features—architraves, pediments, panels, balusters, rustics, and the like. These are not so pure in design, except in a few instances, as those of the best Tuscan work, but there is much more richness and much more play and elasticity about them. One marked peculiarity of this interesting school of buildings is the care with which circular forms are reserved for the interior. I have spoken of the contrast between exterior and interior, and the greater severity of the former; and the causes are no doubt to be found partly in the regularity of arrangement, but also in the severity of the leading forms chosen for the main external features.

Palace after palace may be examined, but in hardly a single instance will you see semicircular or curved window-heads in the front elevation. One arch in the centre, and as large an one as can be introduced without disturbing the symmetry of the first-floor windows, gives access to the interior; and it is even in many instances replaced by a square-headed doorway, decorated by pilasters and a pediment, or the like. You enter through this doorway into a vaulted vestibule, almost always square, and in the majority of instances ascend out of this vestibule up a flight of marble stairs to the level of what is considered the true ground-floor. The principal apartments however are usually on the floor above that, that is to say the first-floor, or—calling the basement, which is on the ground level, ground-floor—on the second-floor. It may serve to render this explanation more intelligible if we remember that these buildings are always either a hollow square, or three sides of one, and that in the latter case, contrary to our practice, the open side is invariably the one away from the entrance. This vestibule, then, is under the main body of the front part of the house, and is often a little obscure, while the view up the great flight of steps and through the open arches into the cortile beyond, is all the more charming from the bright light by which you see it. But the point of view of which the most is usually made is the top of the steps. On mounting the flight and emerging from under the main building you find yourself in the cortile, a sort of cloister, occasionally square, but oftener by far oblong, and the entrance always brings you out into the centre of one of the narrow ends. The most frequently

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repeated treatment is that there shall be two series of arcades surmounted by a balustrade or parapet, but the treatment constantly varies, and the utmost art has been employed to procure vistas and complications of perspective effect. Some interesting object is usually placed exactly opposite you across the court-yard; it is either a statue, or a fountain in a niche, that you see under the arch facing you, or a second marble staircase; or else, where space allows, the end of the cortile is left wholly or partially open, and a gay sun-lit flower garden is seen beyond, its green and its flowers and its pleasant fountains refreshing and charming the eye.

The points most noticeable in the planning of these magical effects seem, first the judicious use made of the power of bringing a spectator to a certain point and arranging a view from that point; then the geometricalness, if I may be allowed the word, of the planning, a quality the importance of which is far too little recognised by us in the present day; then the liberality of it,—there is no stint of space given to the vestibule or the cortile, however difficult it may be to obtain it; and lastly, the copious use of the very form so studiously avoided in the exterior, I allude to semicircular arches. These arcades usually spring from circular Doric columns, whose caps are surmounted by a kind of dwarf entablature consisting of freize and cornice only.

Of course, the circumstances of the site have caused this usual plan to be often modified; and it is one of the curious results of situation that most of the variations occur on one side of the street, namely, that side towards the harbour and where the ground falls away from the entrance level instead of up it. Here occurs the Balbi Palace, with a vast staircase ascending and another one descending—perhaps one of the most beautiful of all intricate staircases known. Here, too, occurs a palace the interior of which fascinated me more than any other in Genoa, the Palazzo Balbi Piovera, already alluded to. In this palace the cortile is on a level with the street, and you see out of the vestibule and through three arches, a long vista, in which arches answering to them occur four times at different distances apart, under different conditions of light and shade, and with a grove of orange trees among them. The staircase in this instance is at one side, and, not being intended to become itself a prominent feature in the architecture, when you ascend it you get no view save a pretty but short cross-vista, and you land at the top with your face to a wall. Of course you turn round, and the utmost skill of the architect (in this instance not Alessi) has been employed to provide a *coup d'œil* to surprise you. You are at one angle of the upper story of the cortile; straight before you runs the upper corridor, a pilastered wall on the right, an airy open arcade on the left, a series of little domical vaults over head, and through the open arch at the end a charming distant view with flowers and the tops of orange trees mingled with it. As a contrast to this one regular vista, if you glance across the cortile anglewise and downwards, as you can from where you stand, the most charming perplexity meets the eye, of arches seen through arches, and orange groves terminating in a half-seen half-hidden glimpse of a pretty little nymphœum out in the sunny garden among the orange blossoms, while the most exquisite play of light and shade, enhanced by your being yourself in a dark angle, has been contrived to add brilliancy to the scene. The whole thing is the very poetry of planning.

The apartments themselves in these buildings are vaulted and fine, but not so as to claim distinct description here; nor can we describe any of the picture galleries, except to remark that when you go to Genoa you must leave no stone unturned to get a sight of the German pictures at the Municipio. The mural painting must however be just mentioned. Some of the older buildings display vestiges of large fresco paintings on their external walls; strange and gaunt now, but looking as if before they had perished and faded they must have had rather a fine effect. The internal frescoes have fared better. A large number of beautiful arabesques were executed here by Pierino del Vaga, a skilful pupil and assistant of Raffaelle, who after his master's death was invited to Genoa by the great Andrea Doria, and settled here. They are very full of grace, and the colours are still rich and fresh. Gauthier gives in his book engravings of some of the finest.

Among the palaces named in the guide-books, but not unlikely to be passed over, is one upon which something ought to be said, the Palazzo Sauli, situate in rather a remote part of the city, and now neglected and fallen into decay. Its disposition is different from the other Genoese palaces, as it is a compact block entered through a fore-court formed by three screen-walls, having a cortile only one story in height within them. The two fronts of this palace are very different, but both good. The fore-court is particularly well designed, and cannot fail to please: there is some fine ornamental stucco-work in the interior.

The custom of making the upper rooms the main house, of course, affects smaller-sized dwellings; and accordingly, though they cannot have a cortile, these mostly have their vaulted vestibule open to the public, with stone or marble stairs to the first floor, and the principal house-door there. And it is something to reflect upon, how much may be effected by simple means and with very limited space, to see how charming many of these entries are made by one or two columns, a partially groined vault, and a plain but tastefully-placed staircase. The private houses contain a good many noteworthy examples of doorways: two of the most famous are to be seen in the Crystal Palace: others exist nearly as fine, and among them a few very good ones of the Gothic period, enriched with quaint sculpture or inscriptions.

Beside other palaces, there are many interesting public buildings that ought not to be passed by, such as the Albergo dei Poveri, the Ospedale, the public granaries, the gate leading to the mole, the lighthouse, the old hall of St. George, the ducal palace, with its noble and rich hall, measuring about 56 feet by 120 feet, and above all the well-proportioned and elegant Loggia dei Banchi: all these are in the prevailing style, as are also most of the churches, and well repay a minute examination.

Among the churches of Genoa the cathedral takes the first place, although it is not the most conspicuous of the ecclesiastical edifices in any general view of the city. It has been very much added to and altered at various times, but appears to have been originally built in the tenth century. It was completed, in fact recast, in the early part of the fourteenth century, and added to and enlarged by Alessi in the sixteenth. The west front, which dates from the year 1300, is tolerably perfect, and is the most interesting portion of the cathedral: it was however left incomplete, for two flanking towers were originally intended, one of which has since been carried out in an incongruous style; and some unsuitable openings have been cut in the lower part of the front. The exterior and the Gothic portion of the interior have the peculiar striped arrangement common in Italian Gothic, being faced with alternate courses of black and white marble. This produces an unpleasing streaky appearance, destructive somewhat of breadth of effect, and which must when the materials were new and entirely free from stain or dullness, have been more visible than now. But in the moulded jambs and heads a skilful employment of these contrasted materials has helped to produce variety: for instance, in the heads of the doorways, the voussoirs are arranged so that their joints shall form lines radiating from the centre from which the arch has been struck; but in the different series of mouldings the white and black voussoirs are contrasted, a black one of one series being made to come opposite to a white one belonging to the adjoining series. This elevation presents three vast and deeply-recessed doorways, with shafts, and simple but rich mouldings; above, the division into three is continued, and the two sides of the building were evidently destined by their architect to have been carried up without any interruption into the two towers. There is a circular window of large dimensions, but scarcely so rich as the doorways would have required. The various alterations however, the incompleteness, and the incongruous additions that have been made, all render it difficult to do more than select details and single portions for admiration. The door on the south side is specially noteworthy; also a very curious niche at the south-west angle, and a pair of marble lions, such as we commonly find associated with the entrances to very ancient churches. The interior contains a curious mixture of Classic and Gothic, thanks to the various rebuildings it has undergone.

Many of the churches of Genoa were destroyed by the French, and of those that remain there is no other Gothic one that need receive special mention. Two or three Renaissance churches of great splendour exist in Genoa, the most conspicuous of which is L'Assompta di Carignano, a large church, dominating over a whole quarter of the city in consequence of the elevated site on which it is built. The architect was Alessi; but this church, though possessing some merit, and especially a finely disposed plan, is far from being his most successful work. It has a very compact plan, occupying a parallelogram of about 170 feet square: this space is occupied by nave and aisles, forming a Greek cross, a

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cupola rising above the crossing, and the four square spaces between the arms of the church being also thrown into it, though not carried up so high as the main portions. There is a pediment at the west, north, and south ends of nave and aisles; and it was intended to erect four towers at the four angles. Of these only two are carried up: they are of remarkably good design; while contrasted with them the central dome appears deficient in height. It rises above a good drum, but appears to spring too soon, and to be crowned by too heavy a lantern. Perhaps one main cause of its rather unpleasing effect is that there are no ribs. The whole cupola is covered with scale-shaped slabs or tiles, and has none of those lines running up it which give such an appearance of vigour and roundness to our St. Paul's, St. Peter's at Rome, the Invalides, and nearly all other celebrated domes. The interior is rather plain but very good, and has some fine effects of light. Every visitor ought to ascend the Carignano cupola to see the splendid view of Genoa, the sea, the harbour and the surrounding hills, which it affords, and also to examine the design of the two western towers. The excellent arrangements for getting access to the roofs and for circulating upon them, deserve attention.

Next in importance stands the Annunziata, a church which probably enjoys the questionable distinction of being the most brilliantly decorated in Italy. It has a nave and aisles with collateral chapels beyond them, and an apsidal choir. The side aisle arches spring from the caps of Corinthian columns, and the entire church is vaulted, and decorated with a profusion of coloured marbles, gilding, enriched mouldings and painting. One great merit is the lighting, which is partly from the clerestory, and partly from windows very high up in the collateral chapels. A somewhat similar church is that of San Siro, the oldest ecclesiastical foundation in Genoa, and remarkable for having coupled columns separating the nave and aisles. The same feature occurs in another church. St. Ambrozio is also remarkable for its richness; and several others exist worth visiting. None of them however seem to belong to so distinctly marked a school as that of the secular buildings.

Genoa is rather famous for its campaniles. These are most of them connected with the suburban churches, and are very picturesque objects, and display some of them a style of treatment which we have not imported into this country, Indeed the suburbs generally are pretty and interesting, and among them some extensive grounds and villas are to be found.

Geometrical division rigorously carried out lies at the root of all excellence in elevation, section, or plan, when designing in Italian styles, but above all in plan; and the examples of Genoa alone go far to prove this, and to justify my venturing to invite your attention to the subject.

ON THE LONGITUDINAL STRESS OF THE WROUGHT-IRON PLATE GIRDER.

By Callcott Reilly.

(*Concluded from page 264.*)

In the table below, the first column is the list of numbered cross sections; the second column contains their respective distances from the abutment A; the third the corresponding values of M; the fourth the areas of the boom under tensile stress; the fifth the areas of the boom under compression. The limits of tensile stress being $f_1 = 5$ tons per square inch; of compressive stress, $f_2 = 4$ tons per square inch; f_1 and f_2 being taken at the centres of gravity of the booms respectively, which by equation (2) are at distances from the neutral axis, throughout the length of the beam—

$$h_1 = \frac{5 \times 24}{9} = 13{\cdot}33 \text{ inches}$$

$$h_2 = 24 - 13{\cdot}33 = 10{\cdot}67 \text{ inches;}$$

then $a_3 = 2 \times 13{\cdot}33 = 26{\cdot}66$ sq. in.; $a_4 = 2 \times 10{\cdot}67 = 21{\cdot}34$ sq. in.

By equation (7) $a_1 = \dfrac{M - 1151{\cdot}26}{9 \times 13{\cdot}33}$

By equation (8) $a_2 = \dfrac{a_1 \times 13{\cdot}33 + 63{\cdot}84}{10{\cdot}67}$

} All but M and a_1 are constant for all the sections.

The substitution of the different values of M and a_1 in the equations successively gives the results in the two last columns of the table.

1. Number of cross section.	2. Distance from A.	3. Values of M.	4. Values of a_1	5. Values of a_2
	Inches.	Inches and tons.	Sq. in.	Sq. in.
1	54	453·4	0·0	0·0
2	108	0·0 (Point of contrary flexure 0_1)	0·0	0·0
3	170	1649·0	4·0	11·0
4	210	3347·4	18·5	29·0
5	246	5302·8	34·0	49·0
6	266	3825·2	22·0	34·0
7	290	2216 9	9·0	17·0
8	329	0·0 (Point of contrary flexure 0_2)	0·0	0·0
9	380	2213·8	9·0	17 0
10	430	2583·3	20·0	31·0
11	492 (Centre of bridge.)	4137·7	24·89	37·08

Remarks. (*See Fig.* 4.)

From A to 0_1, a_1 is the area of the bottom boom.
" " a_2 is the area of the top boom.
" 0_1 to 0_2 a_1 " " "
" " a_2 " bottom boom.
" 0_2 to centre a_1 " " "
" " a_2 " top boom.

Where the values of a_1 and a_2 are 0, a certain area of boom is nevertheless applied to give the requisite rigidity to the middle web.

There being eight girders equally loaded, the quantities in columns 4 and 5 being respectively divided by 8, give the areas of the booms for each of the six inside girders; the two outside ones will require the same areas of booms, because the weight of the parapets about equals the weight of the dead load carried by one of the inner girders.

Verification of the results in the preceding table, as regards the section No. 11 in the centre of the middle span, and disregarding the corrections introduced into the equations (15) and (16):—

For the section No. 11, we take the values of a_1 and a_2 from the table,

$a_1 = 24{\cdot}89$ square inches.
$a_2 = 37{\cdot}08$ "
$a_3 + a_4 = 48$ "
$h_1 + h_2 = 24$ inches.

By equation (9) we have for the position of the neutral axis, disregarding the correction for the thickness of booms,

$$h_1 = \frac{24 \times 37{\cdot}08 + 12 \times 48}{24{\cdot}89 + 37{\cdot}08 + 48} = 13{\cdot}33 \text{ inches}$$

$h_2 = 24 - 13{\cdot}33 = 10{\cdot}67$ inches.
$a_3 = 2 \times h_1 = 26{\cdot}67$ square inches
$a_4 = 2 \times h_2 = 21{\cdot}34$ "

which verify the original data.

As we disregard the corrections, we take the values of I_1 and I_2 from equation (11), then

$I_1 = a_1 h_2^2 = 24{\cdot}89 \times 177{\cdot}69 = 4422{\cdot}69$
$I_2 = a_2 h_2^2 = 37{\cdot}08 \times 113{\cdot}84 = 4221{\cdot}18$

and by equation (10),

$I_3 = \frac{1}{3} a_3 h_1^2 = \frac{1}{3} \times 26{\cdot}67 \times 177{\cdot}69 = 1576{\cdot}06$
$I_4 = \frac{1}{3} a_4 h_2^2 = \frac{1}{3} \times 21{\cdot}34 = 809{\cdot}78$

Whence we recover by equations (14*a*) and (16), instead of F_1 and F_2, the original data f_1 and f_2,

$$f_1 = \frac{4137{\cdot}7 \times 13{\cdot}33}{11029{\cdot}71} = 5 \text{ tons per square inch}$$

$$f_2 = \frac{4137{\cdot}7 \times 10{\cdot}67}{11029{\cdot}71} = 4 \quad " \quad "$$

Verification of the same section No. 11 *in the table*, introducing the corrections necessary to yield the exact values of F_1 and F_2 in equation (16):—

In such a case as is presented by these examples it is quite unnecessary to make these small corrections; nevertheless I

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will do so for the purpose of exhibiting a practical application of the method examined in Prop. 2 and its lemma.

As previously described, it is necessary first to fix the thickness of the booms. It is proposed to build the girders entirely of ½-inch plate, and ¾-inch or three thicknesses of plate will be a convenient thickness for the tension boom at the section No. 11; the compression boom at that section may conveniently be composed of four thicknesses, or 1 inch thick; to give the net areas of the booms as shown in the table with these thicknesses, the breadth of the tension boom must be 33·1867 inches, of the compression boom 37·08 inches. But these breadths must receive a correction, as described in Prop. 2, to compensate for the parts cut off the area of the middle web. When this is done we have (see Fig. 6),

The corrected value of

a_1 = area of rectangle $\overline{A_1B_1}$ = 24·89+0·75 = 25·64 square inches
a_2 = „ $\overline{A_2B_2}$ = 37·08+1·00 = 38·08 „
a_3+a_4 „ $\overline{A_3A_4}$ = 48·00−1·75 = 46·25 „
d_3+d_4 = depth of web = 24·00 −0·875 = 23·125 „

To verify the position of the neutral axis we have, by equation (9)

$$h_1 = \frac{24\times38{\cdot}08+11{\cdot}9375+46{\cdot}25}{25{\cdot}64+38{\cdot}08+46{\cdot}25} = 13{\cdot}33 \text{ inches}$$

which verifies the result of the first calculation;

$$\therefore\ h_2 = 24-13{\cdot}33 = 10{\cdot}67 \text{ inches as before.}$$

To determine exactly F_1 and F_2 we have (see Fig. 6),

$c_1 = 0{\cdot}75$ inch, $c_2 = 1$ inch
$d_3 = h_1-0{\cdot}375 = 12{\cdot}955$ inch
$d_4 = h_2-0{\cdot}5 = 10{\cdot}17$ inch
$a_3 = 2\times12{\cdot}955 = 25{\cdot}91$ square inches
$a_4 = 2\times10{\cdot}17 = 20{\cdot}34$ square inches
$b_1 = 34{\cdot}1866$, $b_2 = 38{\cdot}08$

By equation (10) we have

$$I_3 = \tfrac{1}{3}\times25{\cdot}91\times12{\cdot}955^2 = 1539{\cdot}218$$
$$I_4 = \tfrac{1}{3}\times20{\cdot}34\times10{\cdot}17^2 = 704{\cdot}2479$$

and by equation (14)

$$I_1 = 25{\cdot}64\times13{\cdot}33^2+\tfrac{1}{12}\times0{\cdot}75^3\times34{\cdot}1866 = 4557{\cdot}0452$$
$$I_2 = 38{\cdot}08\times10{\cdot}67^2+\tfrac{1}{12}\times1{\cdot}0^3\times38{\cdot}08 = 4338{\cdot}5391$$

Substituting in equation (15) we have

$$s = \frac{4137{\cdot}7}{4557{\cdot}0452+4338{\cdot}5391+1539{\cdot}218+704{\cdot}2479} = \frac{4137{\cdot}7}{11136{\cdot}05} = 0{\cdot}37154;$$

whence by equation (16)

$F_1 = 0{\cdot}37154\times13{\cdot}33 = 4{\cdot}9527$ tons per sq. inch tensile stress,
$F_2 = 0{\cdot}37154\times10{\cdot}67 = 3{\cdot}9643$ „ „ compressive stress;

Showing that the errors introduced into the original calculation, by the assumption that the booms have no thickness in this instance of a small girder, are extremely small, being less than 0·05 ton per square inch of stress on the side of safety, and may therefore be neglected. If the booms had been 2½ or 3 inches thick, or more, the case would be otherwise, and then a correction might be applied to their areas, after verification by this exact method, to reduce the values of I_1 and I_2 to the same as given in the original calculation by equation (4).

In a small girder like the present example the simple method of verification exemplified previously, which disregards the corrections, will be quite sufficient; and this method is in accordance with formulæ applied to the girders of the Britannia and Conway Bridges by Mr. Pole, in Clarke's 'Britannia and Conway Bridges.'

It is hardly necessary to say that in the design for the girders, the areas of all those parts subject to tensile stress must be increased just so much as will compensate for the loss by the rivet holes; and the joints being brought as near as practicable to the position of the calculated cross sections, must be studied so as to have a strength equal to the nearest greater tabular area. With regard to rivets, no more should be put in than is just required by the strength, of which the area of bearing surface on the rivets is the general limit, and this may be made to equal 5 tons on a square inch. If there is a greater bearing stress the plate and rivet may be expected to cut each other.

CONTINENTAL PUBLICATIONS AND INTELLIGENCE.

We have this month to notice a periodical published in Paris, which, both from its old standing and its intrinsic excellence, deserves careful examination, namely the *Révue Générale de l'Architecture et des Travaux Publics* (General Review of Architecture and Public Works), edited by M. César Daly. This, like the *Encyclopédie*, is published monthly, and similarly contains, besides occasional woodcuts printed with the letter-press, a series of plates engraved on steel or stone; of these each number contains several; the execution of them is admirable, and the selection of subjects usually appropriate. The work has been long established, being now in its twentieth year, and the manner in which it is conducted affords fair ground for supposing that this long popularity will not soon draw to a close.

We propose to give some account of the contents of the first three numbers for the present year, with the advantage that in so doing we are starting from a sort of change in the periodical itself, as some alterations have been recently made in the mode of conducting the publishing part of its business. Each number has its contents classed under three or four divisions, the topics of the first of which are perhaps rather inappropriately entitled "History." Under this head are ranged some short articles on matters of archæological interest, and a series of elaborate papers on Chinese architecture. These are very detailed, and give a long account of the mode of life of the Chinese, as well as the arrangement of their dwellings. "Theory," when it occurs, is placed next; but only one article on a theoretical subject is given in the three numbers to which we are restricting our notice, and this is an able investigation into the theory of Waggon-head or Cylindrical Vaults, written with that clearness which is particularly the quality of French scientific works. After "history," and "theory," follow successively "Practice," "Varieties," a list of books and engravings published, and the plates.

The articles under the head "Practice" appear to be some of the most important, and to have the greatest care bestowed upon them; the aim of the editor being (to use his own words) "to obtain from each architect peculiarly experienced in a special branch of architecture the result of such experience, and then methodically to collate these results in such a manner as to present the most advanced condition of that branch of the art, and in a form the most calculated to enlighten the reader thoroughly, while economising his time."

A series of articles, with copious illustrations, is given on the subject of those schools for the rudimentary teaching of young children, termed *salles d'asyle*, which might be translated "refuges," though it does not appear that these schools are similar in intention or character to the refuges and ragged schools now happily so common among us. They seem rather to be like our district schools; and it appears that the early founders and first teachers came to this country to visit our infant schools, and study the system on which they were conducted. The total number of such schools now in operation in Paris is stated to be fifty-seven, with room for rather over 8000 children; all of them contain a school-room, a covered and an open play-ground, with necessary offices of various kinds, and rooms for the teacher. The plans of two such buildings are given, and show that a system different from the one in use among us must prevail in the working of them. The school-room, instead of the long shape now recommended, and in which a recess is often arranged, is a wide square room in each instance, with a platform of raised seats at one end, like those in our own infant schools, while three or four rows of benches occupy the opposite end and the two sides; the centre being left open for the use of the teacher, and having a desk, black-board, and stands for displaying lessons placed in it; but there are no arrangements shown for dividing the children into classes separated by curtains, and no class-rooms as with us.

In the month of January also was commenced a series of articles on Railway Stations, commencing with a description and plans of the fine terminus in Paris of the Lyons railway; the descriptive account of this is pretty ample, and the plans, sections, and details are very complete, and, as the station has the reputation of being a good one, would be interesting to some of our readers. We subjoin some of the general observations on the requirements of a French city terminus with which the description of this one is prefaced.

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"The requirements of a terminus are as follows. On the departure side: a great vestibule or waiting-hall for travellers, in which are placed the booking offices and the inquiry and *correspondance* offices; rooms for registry of luggage, with their offices; rooms for the use of the *messageries* (stage-coaches and carriers); waiting-rooms for travellers; a departure platform for travellers; an external platform beyond the other, to take the tail of the train, for horses, carriages, and postal service. On the arrival side: a platform for the inspection of tickets; a departure vestibule for travellers; rooms for the distribution of luggage; sundry offices for police, *octroi*, general superintendence, electric telegraph, locomotive and general working departments; a small terminus for goods requiring rapid distribution, namely milk and eatables; a great shed for the business of the trains, and for cleansing and housing carriages; a small workshop for slight repairs; and, lastly, a landing platform for horses and carriages at the head of the train.

"Two opposite systems include the whole of the various arrangements adopted up to the present day to meet the requirements of the several departments just enumerated. One consists in placing the buildings parallel to the line of way; at Paris, the Orleans, Lyons, and Versailles (left bank) stations are examples of it. In the other system the buildings are arranged at the head of the road; examples of which at Paris are furnished by the termini of the North, East, and West lines. Since the construction in Paris of the three termini last named, important modifications have been constantly bringing them, as far as the original buildings admitted of their being brought, into the conditions of stations with lateral arrangements.

"Each of these systems of station has its advantages and disadvantages. The lateral system, very convenient for passengers and for working, is not sufficiently satisfactory in architectural expression; it does not clearly enough point out the entrance to the railway, and often presents as principal feature nothing better than the gable of the great shed. The other system presents externally a more magnificent elevation, and an easier approach for travellers, but often at the expense of convenience of working; for in consequence of the position of the waiting-rooms, luggage-rooms, &c. (placed at the head of the station), passengers have to traverse the entire length of the station to reach that end of the departure platform where the trains are formed, and the luggage has to be dragged along the same course; hence arises confusion and difficulty of working, especially as the times of departure are approaching. When the departure and arrival platforms are very close to each other, the confusion is still further augmented, especially in the great vestibule: this hall being the converging point where several streams cross, the arriving and departing passengers meet, and become perplexed as to which direction they ought to take, and the working is thrown into disorder."

Our readers who are familiar with the French railway system will recognise the correctness of this description, and will not fail to note (as they would more distinctly were the plans of the station of the Lyons Railway before them) how much of embarrassment is introduced by the over-exact system pursued, as well as by the departments of *octroi* and *douane*, with which we have but little, happily, to do.

There are other very interesting articles that we leave unnoticed in the three numbers to which just now we confine ourselves, and the numerous and beautiful plates might well have occupied our attention had we space to spare for them; but we must now conclude by remarking that the English journals are often referred to in the *Révue* at some length; an article in our cotemporary the *Builder* being noticed and replied to, and a long extract from the *Mechanics' Magazine* and another from our own pages being translated and republished.

In the *Encyclopédie* for the last month there is an article on the Responsibility of Architects, and there are some legal decisions, one or two of which contribute (along with that article) to give an idea of the position held by architects in France. M. Lemercier, who is the author of these remarks on responsibility, opens by a reference to a double share of it falling in a measure on the architect, who has not merely to guard against his own blunders or oversights, but is also in danger of being called to account for faults committed by the contractor; and the observations he makes on this head are so apposite to the situation of things in England, that we offer no apology for extracting some of them.

"The difference between the positions of the two" (*i.e.*, contractor and architect) "ought to establish the fact that their interests are distinct. Fraud would be of no advantage to the architect; not so to the contractor, and if the latter gives proof of bad faith, a struggle commences, in which superintendence, however active, runs a great risk of being eluded. The system of granting contracts now in use has still further aggravated the position of architects: the giving the preference in allotting works to the person who offers the lowest price creates untowardnesses, which are multiplied in the case of general contracts, for in this case the person holding the contract applies to a series of sub-contractors, from whom he in his turn requires a diminution of price. Now the enterprise being a speculation, there is always reason to fear, that in order to realise larger returns, or to avoid losses, perhaps ruin, the speculator will endeavour to play false in the quality of materials and workmanship."

With every line of this statement anyone familiar with architectural practice in England will concur, except only that we do not always lie open to the disadvantage of the employment of sub-contractors by a general contractor. This is frequently expressly forbidden in the terms of the agreement; and in the case of many modern builders, especially in London, there would be no disposition to resort to such a course, as large firms themselves can and do now perform all the work in each of the trades employed on a building.

The writer goes on to remark that the responsibility of the architect is recognised by law, and divided into that resting upon an architect who simply prepares the plans for any structure, and that resting upon one who superintends its erection. It is stated to be customary for architects to be employed to furnish the plans only, with or without specification, detailed estimates, and schedule of prices, in the case of buildings at a distance from them, a thing which is not very usual in this country; and it is added that much of the speculative building in Paris is done from plans supplied by architects. It appears that according to French law an architect thus furnishing plans is responsible for all damage accruing to the house built according to them from constructive errors or the employment of improper materials, as far as the same were set forth in the plans or specification. "It has been even decided," it is added, "that the architect who has been employed to make plans is responsible for the ruin of the building if that is traceable to a defect in those plans, even although he may not have superintended the works," only the architect is, under these circumstances, not accountable for defects in the foundation or the use of materials bad of their several kinds.

There appears a division in the opinion of French jurists as to whether an architect when he furnishes plans is responsible for infringement of the police laws and regulations for alignment. The preponderance of opinion, however, seems to be in favour of the view which M. Lemercier also holds, that the architect is not so responsible, but that, (as is the case in the London Building Act, where the architect to works public or private is not in any way referred to,) "the person to whom the execution of the works is confided is the only person bound to act conformably to the laws regulating buildings."

It is added, in case a client desires something to be introduced into the plans that will endanger the stability of the building, and persuades his architect to comply with the wish by undertaking in the event of misfortune to hold him harmless, and himself to bear the responsibility, that notwithstanding this undertaking on the part of the proprietor the accountability of the architect remains undiminished. This opinion would no doubt hold good in England as well as in France, and is unquestionably a sound one; because the architect's first duty before all other things is to have a knowledge of and regulate all the technical part of a building, though he is too often subject to be interfered with in a way that provokes the subjoined caustic remarks:

"The propensity, general as it is, to intrude upon the architect's functions, calls forth naturally enough the somewhat remarkable reflection, that no one believes himself competent to write a symphony or an opera, or paint an historical picture or a portrait, without having studied music or painting; and yet all the world, with very few exceptions, feels quite able to make a plan or superintend works; nay, we may go so far as to say, that there are really now none but architects to whom these two last-named things appear to present any difficulty."

In the case of an architect superintending works it appears that the French law and the decisions of their courts go to prove that even if the plans for the work were not prepared by him, he stands in the eye of the law as having adopted them, and taken upon himself the whole responsibility attaching to the preparer of them; but that a responsibility is only understood to exist in respect of "*gros ouvrages*," which may be translated as the essential portions of the work; and that before the architect can be called to account, faults or defects in construction of some importance must have become apparent, and the building must have suffered from or be in danger of some serious dilapidations or injury; this accountability being held to be exactly similar what-

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ever the character of the works, whether public or private buildings, repairs or new structures.

It further appears that, though the architect will be held accountable for damage resulting from his ignorance or negligence, he will be harmless where the directions he gave were correct as far as could be at the time seen; and then follows a statement which seems to show that the French law in this particular is more considerate than English custom. "The architect would not be responsible for the inexact performance of his orders in cases where the fraudulence of the contractor has frustrated his intentions." It is too much believed in this country that persons having the general control of works are able by their supervision to insure that even work done by a rogue shall be sound and good. It cannot be too distinctly stated that to accomplish this is impossible, and that although superintendence, especially when aided by the constant supervision of an honest clerk of works, is of great value, yet where an unprincipled man has got work to do,—a thing of frequent occurrence under the present vicious system of public advertising for tenders—he is sure here and there to elude the utmost vigilance that can be exerted.

The question of verbal orders is then referred to, and as under circumstances where work is done wholly or partially under such instructions the presumption would be, in the absence of documents or witnesses, that the architect's directions had been all that was requisite, it appears that the whole blame in case of misfortune would be laid upon the contractor, unless he had taken the precaution to get a written indemnification. The subject, as far as this paper (which is to be continued) carries it, is summed up as follows:—

"According to the opinions of the writer, and the decisions we have quoted, we cannot but conclude that the architect is not responsible for hidden defects, nor for failures resulting from fraud, nor for neglect to carry out his orders in dangerous repairs, and that he can only be accused of negligence in superintendence within the limits of practicability."

A further topic is however entered upon, and one in which our own custom is entirely at variance with that of our neighbours. It appears that by the French law all extra works ordered by the architect, in cases where a contract to do a building for a definite sum of money exists, without an authorisation in writing from the proprietor, are at his own risk; and the architect is strongly advised never to give any order in contract works which will lead to additional expense without such a document. This regulation will be more favourable to the pockets of proprietors than to their buildings; and the writer admits it is not very customary to conform to it. In England, as our readers know, the architect is held to act as agent for his employer; and in all building contracts it is customary for him to be empowered to direct any additions or alterations he thinks proper, so much so that we are of opinion it would require a special covenant in the contract, of a very peculiar and unusual nature, to protect the employer from the possibility of having to pay for works or articles not included in his contract with the builder, if the architect thought proper to order them. We may fairly add, that though this privilege is unhappily abused at times, it seems on the whole so necessary and essential a part of that power which the man who is in the main answerable for the success of a building ought to possess, that it is to be hoped it will never be attempted to assimilate our law to that of our neighbours, among whom it seems from this article that neither the power nor the responsibility of an architect are so great as in this country.

Among the legal decisions reported in this periodical is a curious one relating to a division-wall, which is said to be of very great importance to proprietors in Paris, as the circumstances of the case are, in consequence of the immense number of new streets that are being cut, of frequent occurrence. The case is thus stated, according to the method we have already described as the one followed with law notices:—

"The co-proprietor of a party-wall cannot open windows in it without authorisation, even in the case where in consequence of demolitions the wall has come to abut on a public way. In such circumstances the city, occupying the position of the adjoining owner, retains all his rights over the common property. But when openings have been made in said walls by the consent of the executive, the city cannot demand their being closed without offering compensation."

REGENERATIVE HOT-BLAST STOVES.*

By Edward A. Cowper, C.E.

(*With an Engraving.*)

In our last number we gave the first portion with illustrations of Mr. Cowper's paper relating to Hot-blast Stoves heated by coal fires; and now add the remaining part of the paper describing the application of his invention to hot-blast stoves heated by gas.

In Plate XXVII., Fig. 1 is an elevation, Fig. 2 a vertical section, Fig. 3 a sectional plan, of a gas stove to be heated by the waste gas from the top of the blast furnace; Fig. 4 is a plan showing the pair of gas stoves combined. Two pairs of these gas stoves are being erected at some large ironworks in the north of England for blowing a large furnace; they are designed to heat 6000 cubic feet of air per minute to 1300° or 1400°, and to be worked at four-hour changes. The entire stove is encased in an air-tight iron casing or skin to confine the blast within the stove, while the firebrick lining of the casing serves to keep in the heat. The illustrations show the stove during the time of heating up the regenerator, when the gas-valve K, and the air-valve L, immediately behind it, are both open for the admission of gas and air to be burnt in the stove at A, as in an ordinary stove, using the waste gas from the funnel head. The gas passes into the stove in a central jet at A, and there meets with the air that is entering through the annular space M all round it, and on being lit it forms a large flame right up the centre flue N, which turns over at the top inside the dome and passes downwards on all sides through the regenerator B, which entirely surrounds the centre flue N, heating the regenerator in regular gradation downwards, until all the useful heat is absorbed; thus the upper part of the regenerator is very hot, whilst the lower part of the regenerator is very cool. The residue of the heat passes out through the bottom of the regenerator into the circular flues O O, and thence through the valve C, into the chimney P. A large safety valve R, is provided immediately below the gas jet A, as a precaution in case of explosion.

Should it be wished to obtain the very highest possible temperature, this arrangement of heating the regenerator from the top causes those bricks which are subjected to the greatest heat to be free from any pressure, whilst the bricks at the lower part of the regenerator which are subjected to pressure are not required to stand any high temperature. Another advantage of this arrangement is, that even if the area of the spaces between the bricks of the regenerator is very great, there can be no tendency in the products of combustion to mix together in the regenerator, that is for cooler portions to become mixed with hotter portions: for if any portion were to be slower in descending than the rest, it would from this very cause give off more of its heat, and thus become heavier; whereas if any part descended quicker than the rest, it would not lose its heat so fast, and would therefore remain somewhat lighter, and its descent would thus be retarded. The same is the case when the circumstances are both reversed, namely, when the cold-blast is being heated and is ascending; therefore under this arrangement the currents may be as slow as possible, or the regenerator as large as possible, and yet no mixing will take place between the several strata of temperature. It may also be observed in reference to the heating of the regenerator that as the hot end approaches the temperature of the fire, whilst the cold end is at the temperature of the chimney flue, so the temperature of either end varies but little even after several hours' heating, though the heat works further in at the hot end, and there is less length of cold part at the cold end; the regular scale or gradation of temperature of the great bulk of the regenerator is simply shifted lower down in the mass of brickwork, there being a greater length of hot part then left at the upper end. When the stove has been heated for two, four, or six hours, the gas and air valves K and L, are both shut, and the chimney valve C, also; then the cold-blast valve E, and hot-blast valve F, are opened, and the blast at once commences passing up through the regenerator and being heated. Precisely the opposite result now takes place in the gradual shifting upwards of the scale of temperature in the regenerator; until by the long continued action of the cold-blast in taking up heat from each course of bricks in succession there is only a short length of thoroughly heated part left at the top, and a greater length of cooled part left at the bottom of the regenerator, when it is time to change the valves again.

(Concluded from page 279.)

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When changing the stoves it is the practice of course to put the blast on through the fresh stove before shutting it off from the first, and so for a few seconds half the blast passes through each stove. With full-sized stoves the changing will probably take place every four or six hours, according to the degree of variation that it is thought proper to allow in the temperature of the blast. The stoves here illustrated do not contain quite so much brick-work as would be used if it were intended to work at longer times of changing.

The friction or resistance to the blast in passing through the regenerative stoves is not more than through the ordinary stoves, producing a reduction of only $\frac{1}{10}$ lb. per square inch in the pressure of the blast.

The economy of heat obtained by the new stoves as compared with the ordinary is most striking when using gas as fuel: for it has been found by direct experiment that the heat passing away from the ordinary stoves amounts to more than 1250°, and as the temperature produced by the combustion of the gas is about 2000°, the difference or about 750° is all that is taken up by the ordinary cast-iron pipes; whereas the regenerative stoves do not part with the heat at a higher temperature than about 200°, and as the temperature produced is about 2000°, the difference or 1800° is used in place of only about 750°.

The advantages that may reasonably be expected from the regenerative hot-blast stoves are twofold. Firstly, supposing that it is only required to use blast of the usual temperature, the advantages of this plan are the substitution of cheap firebrick surfaces to receive the heat of the fire, in place of the more costly and perishable cast-iron pipes, so that all burning out of pipes and leaky joints are at once saved, while surface for surface firebrick is only a hundredth part of the expense of cast-iron pipes: there is also great economy in fuel, resulting from the fact that all the heat is absorbed in the regenerator before passing away to the chimney. Secondly, the greatest advantage consists in the power obtained of raising the temperature with perfect ease to a much higher degree than ever could be attempted before, and this too with the greatest economy of fuel and materials.

As regards utilising the waste gas from the top of a blast furnace, recent experience both in this country and abroad has fully proved that there is no real difficulty in accomplishing this, either on the plan adopted at the Ebbw Vale works, or on that of Mr. Charles Cochrane, and all doubt on the subject is now removed. The regenerative stoves are particularly well adapted for being heated by gas, as there are no iron pipes to be injured by the gas flame. If it be urged that there is already more gas generated from one furnace than is enough to heat the blast for it, and that therefore it is unnecessary to think of economy, it must be borne in mind, that when the quantity of fuel in the furnace has been reduced to a minimum by the use of very highly heated blast, there will probably be only just enough gas made to heat the blast to the desired temperature, as well as to supply the various boilers for blast and lift engine, foundry purposes, &c.; when this has been done, the quantity of fuel consumed per ton of iron made will be exceedingly small, as there will be no heat lost beyond the radiation and that taken away by the melted iron and the cinder.

There are other considerations worthy of the attention of iron-masters with respect to the regenerative hot-blast stoves, such as the decidedly increased make of iron that will result from a furnace of a given size; the greatly improved power of dealing with certain kinds of ironstone; and the advantage of being able to keep out a large quantity of the impurities always introduced in the fuel, such as sulphur, phosphorus, &c., and thus obtain a better quality of iron.

The author showed a working model of the stove in operation, consisting of a fireclay cylinder with open ends, having a grating at the bottom; it was filled with broken pieces of firebrick, which were heated by a gas-burner below, until the lower layers of firebrick became red-hot. The two ends of the cylinder were then closed air-tight, and a blast of air was forced in at the top from an india-rubber reservoir, which issued at a side jet near the bottom of the cylinder; and the heat of the blast at the jet then melted lead, although the heat at the top of the cylinder at the same time was so low that the upper layer of firebricks was only slightly warmed, and the paper funnel which had been used as a chimney to the stove was not marked or scorched in any way.

In working the pair of coal-burning stoves heating the blast alternately, as described in the paper, some difficulty was anticipated at first in preventing the fire from burning away during the period that the stove was shut and the blast passing through it; but it was found that the fire being situated out of the line of blast was isolated for the time, and the blast did not pass over it, so that the fire became smothered in an atmosphere of carbonic acid gas, and lay smouldering until the next change, the blast passing across the opening of the fire-flue, but producing no draught through it, as the fire-door was closed. When the blast was turned off and the fire-door opened, the fire was at a dull red; and fresh fuel being thrown on it burned up at once, and began to heat the regenerator again.

There was no difficulty in preserving the bearing bars of the fire-grate from giving way whilst exposed to the high temperature of the blast for the two hours, for by using water pipes as the bearing bars with a constant stream of cold water running through them they stood perfectly; the sides of the fire-place were also similarly protected by water boxes, and the sliding door was made hollow with water inside, having india-rubber water pipes to and from it like a water tuyere, allowing the required extent of motion to the door. This construction had proved quite successful in preventing any injury from the intense heat, and the circulating water flowed away only moderately heated: it was proposed also to use hollow valves filled with water for the hot-blast valves in the stoves now about to be put up, in which still higher temperatures would be employed.

Mr. C. W. Siemens explained the action of the pyrometer employed for measuring the high temperatures of blast that had been obtained with the new stoves. A pint of water having been accurately measured and poured into the vessel, the sliding scale of the pyrometer was set up with the zero mark at the temperature of the water as shown on the scale of the mercury thermometer; and a cylindrical piece of copper, made of such a size that its total specific heat should be $\frac{1}{50}$th that of a pint of water, was held on a wire and put into the ordinary testing-hole behind the tuyere, and held in the blast for two minutes. It was then suddenly thrown into the vessel of water, and the rise of the mercury thermometer in the water was read on the pyrometer scale, which was graduated in proportion to the relative specific heat of the copper cylinder and the pint of water, so that each degree of temperature of the mercury thermometer was read as 50 degrees on the pyrometer scale; then by taking the reading of the pyrometer scale and adding the reading of the mercury thermometer for the actual temperature of the water, the exact temperature of the blast was obtained. This pyrometer had now been tried practically for some time for these stoves as well as for stoves of the ordinary construction, and answered correctly for indicating the temperature: for still higher temperatures a piece of platinum would be used instead of copper, and the instrument would then be available up to the highest temperature that platinum would stand.

Mr. J. B. Neilson said, he was much struck on hearing the paper on hot-blast ovens by Mr. Marten, read at a former meeting, with the value of the magazine of heat that existed in the large firebrick core filling the centre of the oven then described, which had the effect of regulating the temperature of the oven, preventing fluctuations arising from irregularities of firing: and in the new regenerative ovens that had now been described, the great capacity of firebrick for heat had been well taken advantage of, and a very important step in advance had been made by giving the means of raising the temperature of blast much above the extreme limit practicable with the present ovens, and he considered this would be productive of the greatest benefit in the working of the blast furnace. The great improvement effected by the use of hot-blast lay in raising the temperature in the blast furnace to such a degree that there was always a sufficient margin of heat above the point of fusion of the iron-ore to insure regularity in the make of iron: for in cold-blast furnaces the heat could only just be raised to the melting point of the ore, and the least deficiency of fuel or a slight increase of moisture in the blast, lowered the temperature below the melting point and interfered with the proper working of the furnace; so little indeed was the heat obtained in a cold-blast furnace above the melting point, that even the additional moisture contained in the blast on a hot day was sufficient to bring on a change from white to black slag in the working of the furnace. But the use of hot-blast gave a great additional

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power of managing the furnace, by raising the temperature so much above the melting point that no fluctuation ever brought it down low enough to cause injury. The great advantage of hot-blast in this respect became sufficiently apparent even when the temperature was raised only 50° or 100° in its first applications; and therefore the very great increase of temperature now obtained in the new regenerative ovens must be expected to be attended with most valuable results in increased yield of furnace and superior quality of pig, owing to greater regularity of temperature in the furnace. There might perhaps be some little trouble at first, he thought, in managing the alternate working of a pair of ovens, but this would soon be got over: the great point however in the regenerative ovens was that the whole heat of the fuel was there taken up and given out into the furnace by the blast. Where high heats were employed with the present ovens a great amount of heat was lost by passing off to the chimney, which it was not possible to take up and make use of in the present construction of ovens; but in the new oven it was astonishing how small a quantity of heat escaped into the chimney, and this must cause a great saving of fuel. The high temperature of blast of 1300° obtained in the regenerative ovens appeared at first scarcely credible; but the statements that had been given of their construction and working showed that this temperature was quite practicable, and even higher temperatures might be obtained. He had always wanted to get a very high temperature of blast, and was convinced that, now the advantages of increasing the temperature of hot-blast had been so clearly established by experience, advantage would be taken of every means to raise it still further. The only question on which he felt some doubt at present was whether the inside of the blast furnace would stand the very high heat obtained: for before bringing out the invention of the hot-blast he had tried its effects in a small furnace 3 feet high and 12 inches diameter, in which he got the temperature up high enough to melt the scoriæ from copper works, and obtained No. 1 cast-iron from it; but the inside of the furnace was also melted down by the very high temperature.* But even if the heat should prove so intense as to make it difficult to keep the furnace in order, it might still be practicable to get over this by some plan of water-casing to protect the sides of the furnace from injury.† In this small experimental furnace the first spiral water tuyere was used, imbedded in fireclay, which was now replaced by the cast-iron water tuyere. There was another advantage, he believed, attendant upon the increased temperature of blast obtained by the regenerative ovens, which consisted in lowering the height of the point of fusion above the tuyeres. By the present use of hot-blast the melting point was already brought down to within, say about 8 inches of the tuyeres; and with the blast raised to 1300° or 1500° he thought it would probably be within 2 or 3 inches of the tuyeres, which would prevent the newly melted iron from being exposed so long to oxidation by the blast, and thereby save waste of iron in the furnace. The saving in fuel effected by the regenerative ovens would be twofold, since there would be less fuel required for heating the blast now that all the heat was made use of, and also less fuel and lime consumed in the blast furnace, owing to the increased temperature of blast; while at the same time more iron would be produced in the time, and of more uniform quality. He did not think there was any danger to be apprehended of injuring the quality of iron by using a hotter blast; for some years ago it was feared by many that if the blast were heated above 300° the iron would be spoilt for foundry purposes; but now it was already heated to 700 or 800 degrees without any such detrimental result being experienced, and he therefore looked forward to the use of still hotter blast without fearing any injury to the iron. The regenerative system, which had been so well carried out in the ovens now described, appeared to him to be applicable with advantage to a great variety of manufactures where at present a great amount of heat was wasted by being allowed to escape into the chimney, which might be intercepted and made use of by means of a regenerator. He thought the application of the plan to gas retorts would be very desirable, for at present the heat in the flues escaped into the chimney as hot as the retorts themselves, and almost as hot as the fuel.

Mr. C. W. Siemens thought the hot-blast stove that had been described was one of the most complete and satisfactory applications of the regenerative system yet made; the perfect regulation of blast obtained by it and of the chemical operations in the blast furnace was a highly important point of superiority over the present stoves. He had been for many years working at the introduction of the regenerative principle, in order to utilise the whole of the heat given out in the combustion of fuel, and had applied it already in furnaces for heating and melting glass, iron, and steel, in some cases with great success. The difficulty attending its adoption had never been with the regenerator itself, but in the mode of carrying out the special application, so as to accommodate it to the particular requirements of each manufacture. For heating the regenerator he was decidedly in favour of using gas instead of coal: for a coal fire gave out a very great and unnecessary heat in the fireplace by radiation, requiring special protection of that part to prevent injury; while gas produced less heat at the actual point of ignition, but quite a sufficient temperature in its combustion. In these hot-blast stoves the regenerative system was carried out very well indeed, particularly in the coal-burning stove, considering the difficulty of shutting in the fire while the blast was on; but in firing with gas this difficulty was done away with; the gas valve was simply shut at the time of change, and all the flame went out, and was then lighted again at the next time of heating up the regenerator. In working the regenerative stoves he thought it was not desirable to get up an intense heat much beyond that to which the blast was required to be heated, in order not to expose the material of the stoves to an unnecessarily high heat, and on this account gas appeared preferable to a coal fire: for gas in burning gave a temperature of about 2000°, and would heat the hottest end of the regenerator to that degree, and then in the return course the blast could be heated nearly to the same temperature, which was at present quite as high as could be made use of. He was so convinced of the superior advantage of gas for heating, that in some cases where he had not got the waste gases from the blast furnace to use he had purposely made gas producers, in order to obtain gas from the fuel for burning instead of burning the fuel direct. A large quantity of fuel was laid on a grate in a very thick layer, say about 3 feet thick, and ignited from the bottom, with a slow current of air passing up through it; then as the carbonic acid formed at the bottom passed upwards through the fuel above, it formed carbonic oxide, which passed off at a moderate temperature of about 300°, mixed with the carburetted hydrogen distilled from the coal, and was conveyed to the stove where the heat was required, and there burnt by admitting the required proportion of atmospheric air.

Mr. C. Cochrane observed that the hot-blast stoves put up at his works at Middlesborough were heated with coal fires as had been described; but where there was any difficulty in burning coals he could confirm the advantage of using gas for heating the stoves. He had seen one of the regenerative gas furnaces employed at Messrs. Naylor and Vickers' works at Sheffield for melting steel, which was working successfully.

Mr. J. B. Neilson asked what were the cubic contents of the firebrick contained in the regenerator in these hot-blast stoves, and the quantity of fuel required to heat them, with the time of heating, and the quantity of blast passed through. At present about 5*s.* per ton of iron made was the general cost for heating the blast to the temperature of about 700° or 800°.

Mr. C. Cochrane replied that each of the new stoves at his works was 9 feet deep and 5 ft. 10 in. diameter, containing 250 cubic feet of firebrick, and heating 1000 cubic feet of air per minute to 1200° or 1300°, the temperature falling to 1150° at the end of each change, or only 150° variation altogether: the stoves worked alternately, being changed every two hours. As regarded the consumption of fuel for heating the blast, the result of eight weeks' work was a consumption of 6 cwt. of coal per ton of iron with the new stoves, instead of 5½ cwt. with the ordinary stoves; but then with ½ cwt. more in the new stoves the blast was heated some 350° higher. In the present case however the new stoves had been working under considerable disadvantage, and there were some defects in construction that would be corrected in the next stoves made on this plan. The iron casing of the stoves was lined with only 9 inches thickness of firebrick, which it was afterwards found ought to have been 14 inches at least; and the fireplace was 3 feet further than it need have been from the stove, as it had been proposed at first to introduce a damper

* This effect probably arose quite as much from the fluxing effect of the scoria as from the degree of temperature obtained.—Ed.

† This is already adopted in many of the best managed furnaces, and has been in use for some time with perfect success; and in furnaces which have a tendency to "work hot" it is an important improvement.—Ed.

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between the fire and the regenerator, in order to shut off the fire when the blast was on, but this was found to be quite unnecessary. When the new stoves were tried under proper conditions, without these disadvantages, and of large size instead of small, he was satisfied that great economy of fuel would result.

Mr. H. MARTEN was much pleased to see this further extension of Mr. Neilson's original idea of the hot-blast, and was convinced that great improvement might be made over the present stoves, so as to obtain a hotter blast. There had been no experience yet of the regenerative stoves in the Staffordshire district; but it was clear that when radiation was so thoroughly prevented, as in this case, all the heat imparted to the brickwork must be communicated to the blast, and go into the furnace, which would produce great economy of fuel, besides giving a much hotter blast than was practicable with the present stoves.

Mr. COWPER stated that the cost of a complete set of four stoves for heating 6000 cubic feet of air per minute for one blast furnace would be about the same as in the case of the old stoves; but if the stoves were made larger, so that two would be sufficient for a furnace, the cost would be less. The cost of heating the blast by the new stoves would be less than with the ordinary stoves, while the blast would be heated up to 1200 or 1500 deg. instead of only 700 or 800 degrees.

Mr. H. MARTEN said that the consumption of fuel was generally about 6 to 7 cwt. of slack per ton of iron made. The iron heating pipes in the present ovens were reckoned to last about seven or eight years with no material repairs; but the new regenerative ovens described in the paper would certainly be less liable to want repair, as there were no iron pipes or joints to leak in them, and the interior was made entirely of a very indestructible material.

Mr. C. COCHRANE said the make of iron had been the largest whilst the new stoves were used, but the effect was not at present sufficiently marked to enable him to state whether it was due solely to the increased heat of blast. The new stoves had been put up to test the practicability of applying the regenerative principle, and supplied blast to only one tuyere out of five, so that the addition of 350° to the blast at one tuyere was equivalent to only 70° at each tuyere, which was little more than the fluctuations of temperature that the furnace was already exposed to with the ordinary stoves, and not enough to afford definite results. A high heat of blast could not be tried properly with the ordinary stoves, as the iron heating pipes would soon be melted down with any great increase of temperature beyond that at present obtained with them.

Mr. J. B. NEILSON had no doubt the make of iron would be considerably increased by the higher temperature of blast given by the regenerative ovens; for in his first experiments on the use of hot-blast, though he could not get more than 70 or 80 degrees rise of temperature, this was enough to produce a decided increase in the make of iron. He was therefore in favour of heating the blast to as high a temperature as practicable. Possibly if a blast sufficiently hot could be employed the iron ore might be melted with lime only, without any coal except what was required to carbonise the ore; provided that the heat in the blast furnace was not so great as to bring down the furnace itself.

Mr. C. COCHRANE said that with the blast heated to 1300° there had been no difficulty in keeping the breast of the furnace near the tuyere in perfectly good order; and thought there was no danger of melting the furnace down by an increased temperature of blast; for a hotter blast merely reduced the proportion of fuel required in the furnace, and the actual temperature in the furnace need not be increased beyond that of the present hot-blast furnaces, so that there would be no danger of injury to the furnace or to the iron made.

Mr. F. J. BRAMWELL observed that the regenerative oven now gave the power of raising the temperature of blast to almost any heat desired, far beyond what was ever before practicable; and the heat in the furnace could certainly be regulated to any desired extent by changing the burden so as to prevent any difficulty from the very high temperature of blast. This was the first instance of a hot-blast oven in which the heated blast did not come in contact with the iron casing containing it; the interior was entirely lined with firebrick, and the iron was not exposed to the high heat of the blast, while the oven was made air-tight by the iron casing outside, since no brick casing would be air-tight. The great advantage of the oven in making use of all the heat of the fuel was plainly shown in the working model now exhibited, which made the blast hot enough to melt lead at the bottom, while within little more than a foot the heat escaping at the top was reduced so low as to allow of a paper funnel being used as a chimney. This showed that the heat was thoroughly taken up by the firebrick in the regenerator; whereas in ordinary ovens the heat in the chimney passed away at about 1200°, the very temperature of the blast in the regenerative oven.

Mr. COWPER stated that the royalty was 6*d.* per ton of iron made. A set of gas stoves were now being applied to a large furnace in the north of England, on the construction shown in the accompanying illustrations, and the results obtained when they were got to work would give the means of ascertaining the extent of their economy.

The SECRETARY stated that he had seen the stoves at work at Middlesborough, and could confirm the statements given in the paper as to the high temperature of the blast from them, and the low temperature in the flue passing from the top of the stoves.

The CHAIRMAN observed that he understood an important application of the regenerative principle was now in progress for the locomotive engines intended for working the underground Metropolitan Railway in London, so that there would be no smoke or fire, and the steam would be all condensed.

Mr. C. W. SIEMENS said he had prepared the designs for these locomotives for Mr. Fowler, the engineer of the railway, as an application of the regenerative principle, with the view of carrying a store of heat in the boiler sufficient for the short trip required, so as to dispense altogether with a fire whilst running, thus getting rid of all objection from products of combustion as well as steam being given off from the locomotives.

ROUND CHURCHES.*

ON the very earliest revival of the study of church architecture in this kingdom, the subject of round churches seemed at once to gain a remarkable prominence, and to have excited a general interest even among people who had little care generally for antiquities or architecture. There is no one who has arrived at the first stage of his architectural catechism who would not be able to say how many round churches there are in England. The four round churches are quite familiar to us. People will go to see a *round* church who would pass by a hundred rectangular ones: partly, no doubt, because the form is rare; partly because it is connected with that little bit of archæology, which the most modern student has picked up, of the relation of that plan to the Holy Sepulchre; and partly from the circular form in itself commending itself to our love of beauty and completeness;—so that of all figures, from the "round O" that children delight in above all the letters of the alphabet, to the globe which is our world, and to the mightier spheres which circle above us in the convex sky, all round things have a peculiar charm for us, symbolising as they do that eternity which the heart of man yearns to as his home.

It may be because the age of imagination has passed away, and that we are become, as most certainly we are, more prosaic, flat, common-place, square-headed, and unideal, that the round form has evaporated from our architecture, and that we can now seldom catch its vanishing image, except in a windmill or a "folly."

Men are said by civilisation to become less angular, and to have their individual points and peculiarities rounded off by rubbing against their neighbours; and if the architecture of the day is to symbolise the existing state of society (as is a favourite and not very false theory), we might expect to find all our buildings with all their angularities smoothed off, and all projecting points rubbed down to the fashion of most polished circles. But I believe that it would be truer, both in fact and figure, to say that our polish and smoothness is all surface-work—little more than a glaze of varnish and a thin veneering; and that all the individual crotchets and ugly corners still exist in the inner man as strongly marked as they do in the ground plans of our houses, the angles perhaps a little *canted* off,—but no well rounded, complete character either in our men or in their buildings.

The day of round buildings has passed away, and yet with them, I think, the most beautiful of all forms, and the most per-

* Abstract of a paper read by the Rev. Thos. James, Secretary to the Northampton Architectural Society, August 11, 1860, on the occasion of the commencement of the works of restoration and enlargement of St. Sepulchre's Church, Northampton.

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fect, if also the most ambitious. Who can fancy the daring tower rising on the plain of Shinar other than a round building, tier upon tier reaching unto heaven? What are the round towers of Ireland, and those far more ancient topes and lâts of India, the works of the early Buddhists, but embodiments of the same spirit of aspiration, striving to express its craving after the Eternal and the Infinite by a form at once most lasting and limitless?

The earliest buildings of all nations are their tombs, and these also, from the same feeling that erected them, are the best preserved. Our sepulchres are the most enduring of our monuments, and those on which the earliest and highest art was bestowed. Leaving out the strange and isolated art of Egypt, the earliest existing tombs of Old Greece and Etruria, and of the further north and east, are, for most part, round, or at least domed and vaulted, and so partially in curved lines. I must omit reference to them, and also to that much larger group of later Roman buildings, such as the Pantheon, the Temple of Tivoli, the Tombs of Cecilia Metella, of Augustus, Diocletian's Palace at Spalatro, the Church of San Vito (a tomb of one of the Tossia family), at Rome, and many other buildings in which the round form is distinctly developed,—and come to those circular buildings of which time has spared both their forms and records, and which are immediately connected with the round Christian tombs, baptisteries, and churches, from which the Holy Sepulchre at Jerusalem and its kindred churches sprang.

I have drawn out a series of circular buildings, the ground plans being chiefly taken from Mr. Fergusson's admirable 'Handbook of Architecture,' a book enough of itself to fascinate a reader into a student. This series will enable you to trace the growth of the round tomb, through a variety of phases, into the Norman form of round church such as our English architects adopted.

Passing from the Classical period, and taking up the buildings of the Christian era of Constantine, we have the tomb of his mother, Helena, who died in 328; and that of his daughter, Constantia, now known as the Baptistery of St. Agnese. They are both nearly on the same plan. An inner circle of double pillars supports the central dome, there is a vaulted circular aisle, and a further outer row of pillars, which is broken by the entrance or forum. Of the fifth or sixth century is the much larger building (its diameter being 210 feet) now called the church of St. Stephano Rotundo, at Bologna. The pillars are all taken from older buildings. This was probably a tomb or a baptistery.

In Santi Angeli, at Perugia, we have almost the identical form, though of much smaller diameter (115 feet), and we here, then, see the first additions to the simple round in the forms of the square porches. At present there is nothing to indicate any place set apart for the holy communion. The tomb of the saint, or the font, would occupy the central point, and though, from the traditions of the catacombs, the tomb might also form the altar, yet we find no divergence from the concluding circular wall for eucharistic purposes till we come to the budding chancel of the Baptistery at Nocera dei Pagani (on the road between Rome and Naples), where a small intersecting circle forms a recess, at the entrance of which, or possibly on the chord of the smaller circle, the altar stood.

The simple curve being once broken, the expansion rapidly increased in various directions, the chancel became yet more developed, and the octagon form, the intervening link between the square and the circle, which had already appeared in the central font, comes out into prominence, sometimes affecting the outer, sometimes the inner arrangement of the building, as is seen in the main ground plan of St. Vitale, at Ravenna. In the plan of S. Lorenzo at Milan, the central part of the original plan strongly marks the combination of the square with the circle, the germ of those foliated geometrical forms which in aftertimes characterised the window tracery and wall panelling of the best epoch of Gothic architecture, but which were for many centuries confined to the ground plans of a series of the smaller class of churches and chapels, closely united in motive and expression to the earlier round churches from whence they sprang.

It is unnecessary to give a mere catalogue of the many circular and octagonal baptisteries still existing in Italy, and at rarer intervals in Northern Europe. Fergusson's 'Handbook,' and the much larger French work by Isabelle, on 'Edifices circulaires,' though referring chiefly to classic instances, will supply ample examples to those who are inclined to exhaust the subject. The baptisteries of Florence and Pisa, and I think of Parma and Modena, the Campanile of Pisa, known as the "leaning tower," are familiar to us all, either by the engravings or still more faithful photographs which every traveller brings home with him; all combine more or less the rectangular with the circular form, and none of them very much exceed or fall short of 100 feet, which may be taken as the average measure of this class of buildings.

It will illustrate better the history of our own churches to direct your attention to the ground plan of St. Tomaso in Limine, near Bergamo, where the arrangement is almost identical with the original plan of the English examples. Travelling further north we arrive at the curious and important church of Aix-la-Chapelle, in which more emperors have been crowned and more important events happened than have been witnessed in any existing church in Christendom. This was built by Charlemagne, and, though overpowered by the accretion of ages, still retains its main features complete. The nave is really a polygon of sixteen sides, but the shortness of each line brings it, in effect, to the character of a circle. Originally a circular niche, as in the Baptistery of Nocera dei Pagani, formed the east end; the present chancel, terminating with a projecting polygonal or many-sided apse which also has all the general effect of a round, was not erected till the fourteenth century. This church was, no doubt, a sepulchral one, and the parent of many similar buildings in Germany. The churches of Nimeguen and Magdeburg seemed to have followed its type, while that of Petersburg (in Germany) keeps to the true circle both in choir and apse, and terminates westward with a large square tower. The Baptistery at Boun, which was of the eleventh century, has the rectangular part as a large western porch, instead of being inserted as a choir, between the round nave and apse. I noticed the hexagonal Chapel of Colbern, on the Moselle, on account of its rare form, and because, by the kindness of Prof. Donaldson, I am able to exhibit very complete working drawings, which in the elevation of vaulting, triforium, and clerestory, give you a good idea of what your own Church of St. Sepulchre's must have exhibited in its pristine integrity, though the plan of St. Tomaso, near Bergamo, shows this more clearly.

The Church of the Holy Sepulchre in Jerusalem, though by no means the first of round churches, was yet the great progenitor of nearly all the round churches of the middle ages, and certainly of all the English ones. It is enough, for an architectural view, that the pilgrims of the Holy Land, from the fourth century downwards, found a round church, or at least a circular enclosure, built over the reputed tomb of our Lord, and that the crusaders of the middle ages, after that earlier church had been destroyed, still saw a church of the same form, though with many anomalous additions, raised over the same holy spot. It was in fond remembrance of that form, so strange to our insular precedents, that individual knights or religious societies built those memorial round churches, four only of which are left us to the present day.

The Holy Sepulchre itself in its present state is a small chapel, about 26 feet long by 18 feet broad, in the centre of the rotunda, which in itself is about 67 feet in diameter, and at the west end of the building. Beyond, to the east, is the choir, presbytery and apse. These are of much later plan than the original design, and of the walls and architectual details very little indeed remains of the older work. A fire which occurred in 1808 destroyed the greater part of the old landmarks, and what has since been built is in the very worst taste—and indeed could not go lower—of Russian ecclesiastical architecture. The number of piers in the rotunda is eighteen—probably twelve in the original rotunda of Constantine; and the walls are divided in the usual manner (and your own church once was) into three stories, ground floor, triforium, and clerestory. Quaresmius, who wrote I think in the seventeenth century, describes the wall of the triforium panelled with sacred subjects in mosaic on a gilt ground, consisting of the prophets Ezekiel, Daniel, and Hosea, the emperor Constantine, and on the north side the twelve apostles. I mention this as indicating the character of decoration which might be added if our rotunda was ever thoroughly restored. The roof was conical, formed of cedar beams, and the top of the cone was truncated by a circular aperture, open to the sky, which as in the example of the Pantheon appears to have been its only opening for the admission of light. Being placed upon a hill of most irregular surface, so great a difference of level existed between the outer soil and the floor of the rotunda, that the entrance-door from the street on the western side opened into the triforium of the interior. The piers of the rotunda were in part circular, as

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ours are,—in part square. The arches in this part were round, though traces of a pointed arcade, the work of the crusaders, still remain in the choir and eastern apse, and a pointed-arch doorway at one of the entrances. How this grew up from the simple tomb hewn out in the native rock to the present uncouth conglomeration, through ages of persecution and superstition, good faith and bad faith;—how infidels desolated and defiled it; how emperors and patriarchs restored and sophisticated it; how Mahometans and Christians fought over it, and Christians one with another;—how legends and traditions obscured its genuine history, and rival churches and sects overwhelmed its primitive form, till the great fire in 1808 left little but fragments of the old walls remaining,—would form a singular and instructive history, but one far too long to be even sketched here.

The ground plan of the Temple Church is the least elegant of all that remain, the round being smaller in proportion to the rest of the building, and forming rather a vestibule than the chief feature of the church. It differs from our own church in having twelve instead of eight piers, and so far has closer resemblance to the plan of the original. In its triple arches, opening from the rotunda into the chancel, it follows its Northampton sister.

We have then the round church of the Temple, built by the Knights Templars,—the round church of Maplestead, by the other great society of the Hospitallers; while in the other two round churches, of Cambridge and Northampton, can be traced no connection with either order, but they sprang in all likelihood from the unaided bounty of individual benefactors: that at Cambridge from some unknown pilgrim or crusader, whose name has perished though his good work remains; that of our own town, from indirect but very convincing evidence, may almost surely be attributed to the first great name in Northampton annals, Simon de St. Liz, first Norman earl of this county, the founder of the castle and of St. Andrews, twice a pilgrim to the Holy Land.

I need hardly tell you how sadly the original form has been marred, even in times to which we have generally given the credit of knowing better. Originally consisting only of a round and an apsidal chancel, the present round pillars were some three or four feet lower than they now are. They supported an open gallery or triforium, and above that was a circular clerestory (not octagonal as we now see it) crowned by a conical roof. The circular aisle (if I may so call it) running round the pillars was groined over. There were a few round-headed windows, some of which yet remain. Probably in the fourteenth century, the roof and vaulting had decayed, and the restorers in those times thought it cheaper to pull down the whole of the vaulting, turn the two lower stories into one, raise the piers, put up pointed arches, insert large windows, add chancel aisles and two more arches into these new aisles, turn the round clerestory into an octagon, and otherwise mar the original design. Subsequently, the tower and spire were added at the west-end; and then, in still more recent times, followed the abandonment of the chancel and its aisles, the accumulation of galleries and pews, stoves and pulpit into the round, so that it has been said—and I know it to be a literal fact—that people have gone into St. Sepulchre's to see the round church of Northampton, and have come out again conceiving that they had mistaken the building, so utterly was its characteristic form obliterated. Now, whether we shall ever restore it to its original form, whether even it is desirable to do so, to make it again "as round as the O of Giotto," I will not undertake to say. When we have placed the congregation in the new nave beyond it, and the choir in the new apsidal chancel still further eastward, it will be time to see what can be done with the round. It will at any rate be a vestibule to the church, at the same time that it forms a most noble baptistery, with the font in the centre. In round churches the round was not always the nave, as it was originally here and in all the English churches: sometimes it formed merely the vestibule, sometimes the nave; sometimes was placed between the nave and chancel, sometimes formed the chancel itself, or the apse eastward of the chancel; sometimes it was an attached chapel, sometimes a detached baptistery or tower. But in all those churches which were distinctly imitative of the rotunda of the Holy Sepulchre at Jerusalem, it formed the western or nave portion.

Symbolically, the round church has its significance; imitatively*, its association; and constructively, its beauty;—but its circular form is not fitted, never was fitted, for devotional and congregational purposes.

There is one case in which it is well suited for liturgical use—viz., for the administration of the sacrament of baptism. To this the round form was early devoted; to this it should be confined. For a ceremony admitting many spectators, directed to one central object, no form could be more beautiful or more convenient. But it is not suited for the Holy Communion; nor for prayer, nor for preaching. Your own experience in St. Sepulchre's, and its present anomalous arrangement, prove this; it was a bold thing, therefore, for a lecturer in this town not long ago, with such an example close at hand, to advocate the round form for English churches. There are fashionable watering-places where the experiment has been tried, and octagon chapels were once becoming popular in London; but even as mere preaching houses, their form is inconvenient, and still less is it adapted to the liturgical services of the Church of England.

It is well therefore that you propose to give up the round for congregational purposes, and place the worshippers in the rectangular portion eastward, reserving the round as a most noble vestibule, and most appropriate and serviceable baptistery, in the centre of which a font worthy of the position may, I hope, soon be placed as a memorial to the late Marquis of Northampton, who took so much interest in the church built by the first Earl of the same title. When the contemplated extension of the church is completed, and the present cumbrous fittings of the round swept away, I can conceive no interior more picturesque and unique than what St. Sepulchre's will furnish to a spectator standing under the western tower, which will then constitute an outer porch.

Before I conclude I would briefly sum up the references which may be drawn from the very cursory and imperfect statements I have made on the very wide and as yet unexhausted subject of round churches. You will at least have seen that our four round churches are only a small remnant of a much larger number which once existed in England, and that these were not invariably connected with the orders of the Templars or of the Hospitallers, though probably in almost every case (the round chapel of Ludlow Castle perhaps being one exception) with some crusader or pilgrim to the Holy Land, and therefore constructed in imitation, more or less direct, of the rotunda of the Holy Sepulchre at Jerusalem; in all which cases, as I have said, the "round" constituted the nave or western portion.

But from the earliest Christian ages, and linking on by subtile but unbroken chain, with ancient Rome and Greece, and indeed, with the monumental history of almost every people, there existed a series of tombs, towers, temples, baptisteries, chapels, of circular or curvilinear form, which had no connection with the Holy Sepulchre (except that it was itself one link in the general chain), and which, quite irrespective of any imitation of that sacred building, are to be traced in the round portion, wherever situated, of the ecclesiastical buildings of the middle ages, and which received its greatest and final development in the many-foiled and many-angled apses, which constitute so striking and beautiful a feature of the finest continental churches.

In contradistinction to the use of the rest of Europe, England kept steadily as a rule to a square east-end, and though at Canterbury, Tewkesbury, and in a few other noted examples, the circular form appears, yet often with obstinate and hardly excusable persistence, as at Peterborough and Westminster, she capped the curved apse with a rectilinear addition, protesting as it were against the foreign element, and reserving the round form for the western end. Round apses have been a favorite resuscitation with modern architects, and where, as in the new chancel of St. Sepulchre's, they can give their reason why, there can be no objection to their introduction; but a new round church we can never hope, never wish to see again; the reason and the feeling for it is past; and its form, which was ill-suited even for the un-reformed church, is doubly so for our own. As a baptismal vestibule, nothing can be grander, but in these days we want too much room for our congregations to be able in a new church to throw away so much space on mere architectural effect. The more incumbent upon us therefore is it to preserve that unique and beautiful feature, when we find it here. The fifth round church in England we shall never see, but we may yet make ours the most remarkable of the remaining four. There is more of the original in Maplestead; more completeness in Cambridge; more splendour of decoration in the Temple; but for size and usefulness, for correct arrange-

* "He with much labour completed a work marvellously constructed, in imitation of the Lord's Sepulchre, according to the manner which he had seen and carefully measured with a measuring rod when he was in Jerusalem."

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ment and artistic effect, for local associations, and above all, for supplying the urgent spiritual wants of a daily increasing parish, the work which your committee has taken in hand, will, if carried out in its integrity, yield to no church restoration, whether of round church or square, and will, when finished, become the glory, as it has been the shame, of Northampton. That work is now thrown upon your hands, and I fully believe you will accept the responsibility and carry it out. Don't trust to great men, or to rich men or to strangers, but do you, the middle classes of Northampton, hold it to be an honour that you have such a church to restore and enlarge, and enlarge and restore it accordingly.

INDIAN RAILWAYS.

THE following rules concerning level crossing gates, bridges, roads, &c. have been approved by the Government of India:—

Level Crossings.

1. That level crossings shall not be allowed within one-eighth of a mile of the ordinary starting points of a first, second, or third class station. The object of this is to prevent the trains when being started passing over the crossings. A train may be estimated not to exceed 500 feet in length, consequently if the crossing is placed somewhat more than 500 feet distant from the points at which trains start, the thoroughfare will not be impeded.

2. That for roads of first-class importance, over which a constant traffic passes two double sets of 13-feet gates shall be provided; the gates being hung so as to shut across the railway when the road is open, and across the road when trains are expected on the railway.

3. As a general rule that gates should not be hung so as to shut across the railway on parts of the line where trains pass at speed; and that this arrangement should only be allowed where the trains are checked as on approaching a station.

4. That for roads of second-class importance, two gates of 13 feet in width each shall be used, and shall be hung so as to shut across the road and when open to fall back along the approach roads.

5. That for roads of third-class importance, two gates of 8 feet in width shall be used, hung so as to shut across the road, and when open to fall back along the approach roads.

6. That the gates in all cases shall be set up at not more than 3½ feet distant from the rails, so as to reduce to a minimum the dangerous space over which things crossing the railway will have to pass.

Over-Bridges.

1. That for roads of first-class importance the width of the metalled roadway in the bridges shall be 24 feet, and the approaches 30 feet, with a metalled portion 24 feet wide.

2. That for roads of second-class importance the width of the metalled roadway in the bridges shall be 20 feet, of the approaches 30 feet, with a metalled portion 20 feet wide.

3. The approaches to over-bridges to have slopes of 1 in 30 where practicable.

4. It is assumed that over-bridges will not be made for roads of little importance.

Under-Bridges.

1. That for roads of first-class importance the span of the bridge is to be 30 feet, and the headway not less than 15½ feet.

2. That for roads of second-class importance, that is such as to require a bridge 20 feet wide, the headway must be not less than 13 feet.

3. That for roads of sufficient importance to require a bridge 12 feet wide, the headway must be not less than 12 feet.

4. That for roads of sufficient importance to require a bridge 9 feet wide, the headway must not be less than 9 feet.

5. That no openings between 6 and 9 feet in width can be considered available for general traffic, unless they have a clear headway of not less than 9 feet.

6. That no opening between 5 and 9 feet in width can be considered to be available as a cattle pass, unless it have a clear headway of not less than 5 feet.

Diversions and Approaches.

1. In ordinary cases road diversions may be made upon the strip of land 15 feet in width granted for a roadway in the land held temporarily by the railway company; so that the formation of a diversion does not necessarily involve the taking up of fresh land for the purpose, but will usually only lead to the road along the temporary land of the railway company in that place being regularly and well formed.

2. That where these diversions occur, the cutting is to be shifted from the outer to the inner side of the temporary land; but if from any local reason danger to the bank or the road is to be anticipated from the proximity of the cutting, the diversion may be otherwise made.

3. The general character of a road diversion or bridge approach will be made to correspond with that of the original line of road intersected by the railway, though it will occasionally be expedient to metal such diversions or approaches, though the original was not metalled.

Approaches to Stations.

1. Where a station is placed near a road of importance which crosses the line of railway, and on which the cross traffic not using the railway is likely to be of more importance than the traffic to the station and using the railway, the direction of the original road ought to be maintained, and the approaches to the station made by branch roads diverging from the main road, the station being removed so far from the road-crossing as may be necessary for safety or convenience.

2. On the contrary, where the principal traffic in a road leading to a station is likely to be traffic using the railway, the approach to the station should be made as direct as possible, and the road for carrying the traffic across the line should be made to diverge so far as is necessary to place the crossing at a convenient or safe place.

OUTLINES OF THE PRINCIPLES AND PRACTICE INVOLVED IN DEALING WITH THE ELECTRICAL CONDITIONS OF SUBMARINE ELECTRIC CABLES.

By WERNER and C. W. SIEMENS.

(*Concluded from page* 268.)

APPENDIX No. 1.

Resistance of Short Cables.—One pole of a battery of N elements is joined to the cable, while the other pole is to the earth; then if φ represents the angle through which the galvanometer is turned to bring the needle again to zero, the following equation is established:—

$$\sin \varphi = \frac{nE}{x + w_1}$$

E representing the electromotive power of one element, x the unknown resistance of the cable, and W_1 the resistance of the galvanometer.

In order to arrive at the actual value of the insulation resistance, a known resistance, say of 10,000 units, is introduced into the circuit instead of the cable, the sensibility of the instrument weakened (to $\frac{1}{100}$) by a branch resistance W_2, and the number of cells reduced to one.

Another equation is then obtained, in which I may represent the force of the current in the whole circuit to be

$$I = \frac{E}{10{,}000 + \frac{W_1 \cdot W_2}{W_1 + W_2}}$$

and the strength of the current passing through the galvanometer will be

$$i_1 = \sin \varphi_1 = \frac{W_2 \cdot E}{W_1 + W_2} \cdot \frac{1}{10{,}000 + \frac{W_1 \cdot W_2}{W_1 + W_2}}$$

and because $W_1 = 99 W_2$,

$$i_1 = \sin \varphi_1 = \frac{E}{100} \cdot \frac{1}{10{,}000 + \frac{99}{100} W_2}$$

$\frac{99}{100} W_2$ being with our instrument equal to 70 units, we obtain by introducing, instead of 10,000 units, 9930,

$$\sin \varphi = \frac{E}{100} \cdot \frac{1}{10{,}000}$$

Eliminating E from the first formula, and combining it with the second one, we obtain

$$x = n \frac{\sin \varphi_1}{\sin \varphi}$$

in which formula x is given in millions of units.

APPENDIX No. 2.

Specific Resistance of Insulating Materials.—Derivation of the formula for calculating the *specific* insulation resistance. Mr. Werner Siemens obtained the same formula which Prof. W. Thomson arrived at in a very elegant manner in a more simple way.

If dx represents the thickness of a differential cylinder at the distance x from the length axis of the cable, its resistance will be

$$dw = \frac{dx}{2\pi\lambda l x}$$

and the whole resistance equal to

$$W = \frac{1}{2\pi l \lambda} \int_r^R \frac{dx}{x} = \frac{ln \cdot \frac{R}{r}}{2\pi l \lambda}$$

APPENDIX No. 3.

Table of Specific Induction.—In the table containing the results of the experiments of specific induction, the following is the explanation of the different columns:—Column No. 2 contains the descriptions of the cables subjected to the test; 3, the lengths thereof; 4 and 5, the outer and inner

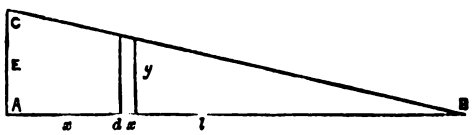
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Number.	Cable material.	Length.	Radius. Inner r.	Outer R.	R/r	Temperature. F	Number of cells (Tension).	Deflection φ.	Constant of the instrument.	Sin φ / ln	Specific induction ln R/r / 2πl C (Gut.-pa. = 1)
1	Gutta-percha	A ¼ mile	4	16	4	51	7	20·3	1	9·92	1·06
	,,	,,	..	.	..	72	5	25	1·7	9·82	1·07
2	,,	B ¼ mile	..	.	..	51	7	20·1	1	9·9	1·06
3	,,	A+B	..	..	..	..	7	43·4	1	9·8	1·05
	,,	,,	..	..	..	..	5	29·1	1	9·7	1·04
	,,	,,	..	..	..	..	3	16·5	1	9·5	1·02
4	,,	A ½ mile	2	14	7	..	7	14·5	1	7·14	1·07
5	,,	B ½ mile	..	..	..	..	..	14·2	..	7	1·05
6	,,	A+B	..	..	..	..	..	28·5	..	6·8	1·048
7	,,	A ½ mile	..	10	2·5	..	..	12·3	..	14·2	1
8	,,	B ½ mile	..	..	..	..	..	12·2	..	14·2	1
9	,,	C ½ mile	..	..	..	..	..	12·5	..	14·4	1·002
	,,	,,	..	..	..	72	2	15·4	1·7	14·5	1·003
10	,,	D	..	.	.	51	3	12·5	1	14·4	1·002
	,,	,,	..	..	.	72	2	15·4	1·7	14·5	1·003
11	,,	A+B	..	.	..	51	3	25·6	1	14·4	1
12	,,	A+B+C	..	..	..	..	..	40·3	..	..	1
13	,,	A+B+C+D	..	..	..	..	..	61·0	..	14·38	0·999
14	,,	A 1 m	2	8	4	..	..	16·2	1	9·3	1
	,,	,,	..	..	..	72	2	17·8	1·7	9·4	1·2
15	,,	B	..	..	..	51	3	16·6	1	9·5	1·208
	,,	,,	..	..	..	72	..	31·1	1·7	9·4	0·99
	,,	,,	..	..	..	92	..	25·9	1·45	..	0·99
16	,,	A+B	..	..	..	51	..	34·6	1	9·38	1·003
17	,,	A 1 m	1	7	7	51	3	11·4	1	6·58	0·99
	,,	,,	..	..	..	72	..	20·6	1·7	6·4	0·99
	,,	,,	..	..	..	92	..	17·7	1·45	6·5	1·2
18	,,	B 1 m	..	..	..	51	..	11·4	1	6·58	0·99
	,,	,,	..	..	..	72	5	31·8	1·7	6·49	1
19	,,	A+B	..	..	..	51	3	22·8	1	6·47	0·98
20	,,	A 1 m	1	4	4	51	..	16	1	9·18	0·99
	,,	,,	..	..	..	72	2	19·4	1·7	9·2	1·02
21	,,	B	..	..	..	51	3	16	1	9·18	0·99
	,,	,,	..	..	..	72	5	28·4	1·7	9·2	0·99
	,,	,,	..	..	.	92	3	24·6	1·45	9·19	0·98
22	,,	A+B	..	..	..	51	3	32·8	1	9·03	0·97
23	,,	A ¼ m	1	13	13	..	..	4·8	..	5·6	1·12
	,,	,,	..	..	..	72	5	16·2	1·7	5·5	1·09
	,,	,,	..	..	..	92	5	14·9	1·45	5·5	1·09
24	,,	B ¼ m	..	..	..	51	3	4·8	1	5·6	1·12
25	,,	C ¼ m	..	..	..	..	..	4·8	1	5·6	1·12
26	,,	D ¼ m	..	..	..	..	..	4·8	..	5·6	1·12
27	,,	A+B	..	..	..	..	..	9·2	..	5·3	1·10
28	,,	A+B+C	..	..	..	..	..	13	..	5·2	1
29	,,	A+B+C+D	..	..	..	..	..	17·9	..	5·12	1·1
30	Hearder	450 yards	2	6	3	..	..	5	..	13	1·24
31	Wray	A 1 m	1	7	7	..	5	15	..	5·17	0·77
	,,	,,	..	..	..	72	3	16·1	1·7	5·2	0·625
	,,	,,	..	..	..	92	3	..	1·45	5·4	0·96
	,,	,,	..	..	..	51	..	8·8	1	5·1	0·77
32	Silver	B 1 m	1	6·2	6·2	51	5	15·9	1	4·8	0·67
	,,	,,	..	..	..	72	3	14·5	1·7	4·9	0·696
	,,	,,	..	..	..	92	..	12·6	1·45	5	0·705
	,,	,,	..	..	..	51	5	14·2	1	4·8	0·68
	,,	,,	..	..	..	72	..	18·1	1·7	4·8	0·619
33	,,	C 1 m	1	7·2	7·2	51	..	12·8	1	4·45	0·66
	,,	,,	..	..	..	72	3	12·9	1·7	4·3	0·518
	,,	,,	1	7·2	7·2	92	3	11·6	1·45	4·7	0·696
34	,,	,,	..	..	..	51	5	13	1	4·5	0·69
	,,	C+B 2 m	..	.	..	5	27·6	1	4·65	0·69	
	,,	,,	..	..	..	..	27·6				
35	Hall and Wells	A 1 m	1	4	4	51	5	34·6	1	11·3	1·21
	,,	,,	..	..	..	72	1½	18·6	1·6	11·6	1·38
	,,	,,	..	..	..	92	3	32·9	1·6	11·6	1·32
	,,	,,	..	..	..	51	5	35·2	1	11·5	1·21
36	,,	B 1 m	..	..	..	..	..	25	1	8·45	0·92
	,,	,,	..	..	..	72	3	26·8	1·7	8·5	0·91
	,,	,,	..	..	..	92	3	23·8	1·45	8·5	0·997
	,,	,,	..	..	..	51	5	24·2	1	8·2	0·92
37	Hughes	A 1 m	1	6	6	51	5	16·4	1	5·66	0·83
	,,	,,	..	..	..	72	3	17·8	1·7	5·67	0·84
	,,	,,	..	..	..	92	3	16·2	1·45	5·65	0·88
	,,	,,	..	..	..	51	5	16·6	1	5·66	0·83
38	Many coatings	,,	1	7	7	51	5	19·3	1	6·61	1
	,,	B 1 m	..	..	..	..	..	..	1	6·61	1
	,,	,,	..	..	..	72	3	20·2	1·7	6·62	1·03
	,,	,,	..	..	..	92	..	17·7	1·45	6·62	1·04
39	Gutta-percha sp.	A 1 m	1	4	4	51	5	21·2	1	7·23	0·74
	,,	,,	..	..	..	72	3	20·6	1·7	7·23	0·74
	,,	,,	..	..	..	92	..	18·1	1·45	7·3	0·766
	,,	,,	..	..	..	51	5	21·4	1	7·29	0·445
40	,,	B 1 m	..	..	..	..	..	20·2	1	6·9	0·74
	,,	,,	..	..	..	72	3	20·9	1·7	6·93	0·754
	,,	,,	..	..	..	92	..	18·4	1·45	6·9	0·75
	,,	,,	..	..	..	51	5	20·3	1	6·95	0·74
41	,,	C 1 m	1	7	7	51	..	90·4	..	..	0·74
42	Radcliff	A 1 m	1	7	7	51	5	21·2	1	7·23	1·09
	,,	,,	..	..	..	72	3	22·1	1·7	7·3	1·1
	,,	,,	..	..	..	92	3	18·8	1·45	7·3	1·1
	,,	,,	..	..	..	51	5	21·4	1	7·23	1·1
43	,,	B	1	7	7	51	5	22·4	1	7·62	1·16
44	,,	,,	..	..	..	72	3	22·9	1·7	7·63	1·15
	,,	,,	..	..	..	92	..	19·4	1·45	7·63	1·15
	,,	,,	..	..	..	51	5	22	1	7·59	1·14
45	Godefroy	1 m	1	4	4	51	..	30·6	1	10·18	1·08
	,,	,,	..	..	..	51	5	31	1	10·3	1·1
	,,	,,	..	..	..	72	1½	15·4	1·7	10·3	1·12
	,,	,,	..	..	..	92	3	28·8	1·45	10·6	1·12
46	Gutta-percha	,,	..	..	..	51	5	38·6	1	9·57	1·1
	,,	,,	..	..	..	..	..	31	1	9·57	1·08
47	Siemens	500 yards	..	..	..	51	5	8·1	1·7	7·3	0·77
	..	390 yards	..	..	..	72	5	6·5	1·45	7·4	0·78

radius of the covering; 7 gives the temperature of the water in which the cables were submerged; 8, the number of elements employed for the test; 9, the angle through which the instrument had to be turned to bring the needle again to zero; 10, the constant of the instrument; 11, the charge observed by the instrument reduced to one element and to the unit of length; and at length, No. 12, the specific induction of the different materials, the mean specific induction of gutta-percha taken for unit.

Appendix No. 4.

Charge and Distribution along the Wire.—Let A B represent a given length (l) of uncoiled cable, the end B of which is to earth, and A C the electromotive force E of a battery, one pole of which is in connection with A, the other pole being to earth. Then, according to the law of Ohm, supposing the cable to be of equal section and conductivity throughout, the curve of the electromotive force, at any point along the line is indicated by C B.



In 1849 (see 'Poggendorf's Annalen') Werner Siemens proved that when a current is sent through a submerged cable a quantity of electricity is retained in charge along the whole surface, being distributed proportional to the tension of each point.

Thus, the tension of the electricity on any small intermediate given length, $d\,x$, of the conductor, at the distance x from A, may be represented by y; the quantity of electricity, $d\,q$, by which the outside cylinder $d\,x$ is charged, according to the formula given previously for induction in cables:—

$$dq = y\,.\,\mathrm{K} = y.\,\frac{2\,\mathrm{I}\,\pi\,d\,x}{ln\,\frac{\mathrm{R}}{r}}$$

This quantity of electricity $d\,q$, has to pass through the resistance of section x, in order to arrive at $d\,x$.

The resulting current developes $d\,q$ in the time $d\,t$, and we have accordingly the equation—

$$dq = \frac{\mathrm{E}dt}{\frac{x}{r^2\pi\lambda}} = \frac{\mathrm{E}r^2\pi\lambda}{x}\,dt$$

By combining these formulæ a differential equation is obtained:

$$\frac{y\,.\,2\,\mathrm{I}\,\pi\,.\,dx}{ln\,\frac{\mathrm{R}}{r}} = \frac{\mathrm{E}\,.\,r^2\pi\lambda}{x}\,dt$$

By eliminating y and substituting its equivalent

$$\mathrm{E} : y = l : l-x$$

$$y = \frac{\mathrm{E}\,(l-x)}{l}$$

into the differential equations, we obtain

$$dt = \frac{2\,\mathrm{I}}{l\,.\,r^2 ln\,.\,\frac{\mathrm{R}}{r}\,\lambda}\,.\,x(l-x)dx$$

$$t = \frac{2\,\mathrm{I}}{l\,.\,r^2\,ln\,.\,\frac{\mathrm{R}}{r}\lambda}\int_0^l .\,x(l-x)dx$$

$$= \frac{2\,\mathrm{I}}{l\,.\,r^2 ln\,.\,\frac{\mathrm{R}}{r}\lambda}\,.\,\left(\frac{l^2}{2}-\frac{l^3}{3}\right)$$

$$t = \frac{\mathrm{I}\,.\,l^2}{3r^2\lambda\,.\,ln\,\frac{\mathrm{R}}{r}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

Appendix No. 5.

Table of Insulation.—The annexed table gives specific resistances. The figures are arrived at by means of the formula given in Appendices 1 and 2 from deflections due to a given number of cells and a certain constant of sensibility to be multiplied by 10^{18}.

These figures, therefore, represent in trillions of units the specific resistances as compared to that of mercury. Certain variations may be partly due to the application of the high battery power which the cables had been previously subjected to, and to insufficient time allowed for the heat to penetrate through the coiled cables, and to various other causes.

Notwithstanding these irregularities, however, the wide differences between gutta-percha and india-rubber and Wray's mixture are very apparent.

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Table of Specific Resistances of Insulating Materials.

Materials.	R	r	32° Fahr.			52° Fahr.			72° Fahr.			92° Fahr.		
			Number of Elements.	Deflection.	Sp. R.	Number of Elements.	Deflection.	Sp. R.	Number of Elements.	Deflection.	Sp. R.	Number of Elements.	Deflection	Sp. R.
Gutta-percha ...B	13	1	...	..	...	256	5·6	0·916	64	16	0·5	64	19·2	0·325
,, ...A	13	1	...	...	...	256	3·6	1·45	...	12·5	0·637	...	16·9	0·368
,, ...A	7	1	512	2·8	4·40	128	2·6	2·63	...	21·9	0·969	32	20·2	0·407
,, ...B	4	1	...	...	...	128	...	...	...	36·7	0·85	16	26·5	0·221
,, ...B	8	2	...	...	...	64	2·4	1·89	...	70·8	0·538	...	21·6	0·264
,, ...A	10	4	...	...	...	256	13·2	1·09	...	30·6	0·996	...	11	0·393
,, ...B	10	4	...	...	...	256	6·4	2·23	..	21·9	1·03	...	9·6	0·447
Silver .....B	7·2	1	...	...	...	256	1·4	48·9	512	4·4	41·3	512	4·6	31
,, ... C	6·2	1	...	...	...	256	1·2	52·4	...	3·4	49·0	...	5·3	24·3
Wray.....	7	1	...	..	...	256	2·6	23·6	...	6·4	26·0	...	15·7	38·4
Siemens	4	1	...	...	...	256	0·5	38·4	...	1·1	49·55	...	0·9	38·4
G. P. special ...A	4	1	...	...	...	128	21·4	2·25	...	21·1	8·25			
,, ...B	4	1	...	...	...	128	4·7	9·44	64	6	4·86	32	1·3	8·38
,, ...C	7	1	...	...	...	512	5·5	22·9	...	...	...	...	8·6	1·55
Hughes	6	1	...	...	...	64	16·7	1·05	8	18·9	0·153	8	11·6	0·191
Many coatings ...	7	1	...	...	...	256	8	7·86	256	21·4	3·98	32	12·8	0·696
Hall and Wells A	4	1	...	...	...	64								
,, B	4	1	...	...	...	128	...	...	128	8·3	5·53	256	27·5	3·11
Radcliff .....A	7	1	...	...	...	128	Faulty	...	2	15·9	0·041	2	11·2	0·057
,, ...B	...	...	...	...	...	16	8	0·48	16	15·0	0·350	16	8·6	9·642
Godefroy	...	...	...	...	...	...	...	...	16	14·9	0·496	16	13·2	0·432

THE BRITISH ARCHÆOLOGICAL ASSOCIATION.

(*Concluded from page 254.*)

We continue the description of Buildwas Abbey. At the east end of the nave and intersection of the transepts stands the tower, which rose but little above the roof, a rule of the order requiring the belfry to be only of moderate height. The tower is carried by four pointed arches. The two which occupy a transverse position are not carried by shafts, as are the side arches, but by corbels, which offer no obstruction to a clear view eastwards. At the east end stood the high altar, and over it originally, as the stonework distinctly shows, were two rows of three round-headed windows; by the removal of the heads of the lower and the cills of the upper, the two were altered into three long windows, as they now exist. This alteration, very greatly to the advantage of the architectural effect, was probably executed whilst the building was in progress. The window on the south side of the chancel corresponds in length with those in the east end, but was originally only a short one, corresponding with the upper row of the east end. The continental churches usually had apsidal chancels, with numerous chapels: in England we have, I believe, no Cistercian example of the kind. The mother-church of the order, Citeaux itself, had a square east end. In the original Cistercian churches the chancel was always short, as we see it here,—frequently so short as not to admit of side windows (it is so at Boyle); but in the thirteenth century many of the chancels were rebuilt of greatly increased dimensions. The mode of vaulting adopted or intended in the chancel is puzzling to discover: what remains of it clearly belongs to the original work, but the springing is so high that the roof over it could not have been constructed in the ordinary way with beams; possibly it may have been intended for a solid stone roof. The sedilia on the south side of the chancel are of ornamental character, and evidently were inserted, probably about 1220. Simplicity of style is strongly marked throughout the church, and was in strict compliance with the institutes of the order. Stained glass and sculpture were forbidden, and we see the injunction was strictly adhered to in the latter point. This law, like others, soon became obsolete. In the church at Boyle, which we have seen to be only a little later in style than this, and the consecration of which was in 1218, strictly as it accords with the Cistercian rule in its general style and arrangement, sculpture on capitals and corbels, representing Scriptural and religious subjects, was used with considerable freedom.

Immediately on leaving the church by the monks' door, a door on the right opens to a descent through the transept wall. The descent leads to a narrow crypt extending across under the transept and its northern chapel. The crypt is lighted by a small window in its east end, and one near that end on its north side. Opposite the east window is a credence and piscina. In the space thus lighted at the east end stood an altar, the crypt being used for the reception of the dead until the last solemnity of interment. The north transept extends itself into a long range of building, forming the eastern side of the cloister. Passing on from the crypt door, the next opening is the door from the cloister into the sacristy. The sacristy is immediately outside the end of the north transept; another door enters directly from the transept, as has already been seen. The sacristy has at some time been converted into a passage-way, by opening an archway in its west end. Again proceeding in the cloister, we come to a handsome entrance archway of semicircular form, between two Norman windows: this belongs to the chapter-house, the floor of which was three or four steps below that of the cloister. The roof is vaulted or groined in nine bays, and supported by four slender columns. Three windows to the east, and one to the north and south, all of Norman character, lighted the apartment.

On the north side of the chapter-house a vaulted passage led from the cloister to the gardens and buildings lying to the eastward. The doorway in the east-end has been stopped up, so that it is no longer a passage-way. The stopped door, moreover, does not appear to belong to the original work, but seems to have been inserted when, in prolongation of the passage, some buildings were added eastwards. Continuing the investigation along the east side of the cloister, we find, about 4 feet north of the passage-door we have just left, the commencement of a wall which extended westwards. This was found to be the north boundary of the cloister-court. We may therefore now complete the account of the cloister by considering what stood on its north side, and of these buildings no trace remains beyond the abutment of the wall just noticed. The buildings were however important. In the centre, and presenting its end to the court (if the Cistercian custom was as fully observed as in the buildings we have considered) was a long and lofty hall or refectory, in which the monks and lay brothers took their meals; west of the refectory, and filling up the space on that side of it, would probably be found the kitchen, with a court and offices of its own in the rear. Somewhere here, too, must have been the stair to the dormitory of the monks, which extended over the chapter-house and its adjuncts, and had access, as has been seen, to the north transept of the church. Of the arcading and shelter which formed the cloister, of the lavatory which was placed opposite the refectory, and of the graveyard the cloister inclosed, which held the remains of the departed inhabitants, scarce a trace or memo-

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rial remains; a few shattered remnants of gravestones have been collected, and now lie in the chapter-house.

From Buildwas the excursionists proceeded to Benthall, the road thereto lying through a most interesting district, including Coalbrookdale, with its celebrated casting works, the products of which are world-famed;—Coalport, noted for its delicate manufactures in porcelain and china;—Madeley Wood, with its iron furnaces; and Broseley, with its pipes and pottery. The object of the visit to Benthall was to inspect the mosaic and encaustic tile works of Messrs. Maw and Co., which were fully explained to the visitors, and the different materials and processes practically brought under view.

A few miles from Benthall is Wenlock, a quaint old town, famous for its priory and church. Of the former an excellent description was given by Mr. E. Roberts, from which we cull the following:—He said it was, without exception, in all respects the greatest ecclesiastical structure in Shropshire, and one of the earliest foundations of the kind in the kingdom. Its date is about 680, and it was founded by Milburga; but not a vestige of that building remains. Milburga was the first abbess of the foundation, and of course she became a saint in due time. Soon after that the Danes seem to have destroyed the church, which at that time was no doubt a wooden one. It was destroyed twice; once by the Danes, and again in some internecine feud. Mr. Eyton, whom he believed to be the best authority on the subject, remarks that Wenlock Abbey was not only the largest, the wealthiest, but the most magnificent of all the religious houses of Shropshire. As compared with the other abbeys, Wenlock was at least double the value. Some parts of the structure were Norman or semi-Norman. That style ran over a period of seven centuries. What is called Saxon differed little from Norman, the Saxon being ruder. The chapel was of the latest part of that period; the other portions are of the early part of the Early English period. Almost all of these foundations are of Saxon origin. The second founder of Wenlock Abbey was Leofric, Earl of Mercia, and Godiva, his wife, between 1017 and 1071, but that was soon destroyed. The first Norman Earl of Shrewsbury was its third founder. All the remains of the church show that it was of the Early English period of the thirteenth century. Mr. Roberts then proceeded to say that he had made a plan of the abbey from actual measurements, and said that he should make it his business to compare it with other plans and drawings, in order to see the depredations which have been made within a comparatively few years. After proceeding through various parts of the ruins, and pointing out the remaining traces of great beauty, he stated that the abbey had evidently not been built from any prepared plan, but that the master builder being an architect, worked out the design as the building was in progress. The abbot's lodging is the most perfect portion of the abbey which remains, and two centuries later than the church itself. It is of the Tudor period. The abbot's parlour and dining-room are accessible from the gallery as well as from the stairs. This portion of the building is undergoing restoration by Mr. J. M. Gaskell, M.P., the owner of the property.

After the party left the abbey they visited the church and the fine old rooms in the Town-hall, the carved oak in the latter place exciting much attention. Between five and six o'clock the excursionists took their leave of Wenlock, and a portion of them proceeded to Acton Burnell Castle.

On the succeeding day the party visited Tong Church, the peculiarities of which (and they are many) were pointed out by Mr. Horman Fisher; and thence proceeded to Shiffnall, the fine old church of which, in spite of marks of recent restoration, its grand open-timbered roof, and the monuments to the family of Brigges, of Haughton, were briefly commented upon by the Rev. J. L. Petit. The ruins of Lilleshall Abbey were next investigated, under the direction of Mr. E. Roberts, and afterwards those of Stokesay Castle, an eminently valuable relic of antiquity. Entering through a beautiful gateway, constructed of modern framework, enriched with curious carvings in excellent preservation, the visitor finds himself in a spacious quadrangular courtyard, on one side of which are the remains of the ramparts, the other being occupied by the house, the offices, and the tower. The whole has been surrounded by a moat. The entrance to the great hall, which is 54 feet by 32 feet, is by a painted doorway. In the 19th Edward I. (1291) the castle received a license for being crenelated to Henry de Ludlowe. The great chamber, or solar as it is called, was of course visited. It is wainscoted with oak, and has a modern insertion of a chimney-piece, richly carved in wood. The tower, an irregular polygon, rises from the south-west corner of the court, and is crowned with an embattled parapet. Close upon the castle is the church, dedicated to St. John the Baptist. In the churchyard are some quaint epitaphs on the grave-stones.

Leaving this place the excursionists proceeded to Ludlow, passing Bromfield priory and church, with Oakley-park, on the right; and Stanton Lacy church, a mile or so on the left. Ludlow castle and church (the latter recently restored, as we described in our July number) proved highly interesting objects of study, as did the still more antiquated remains at Haughmond Abbey, Battlefield Church (on the site of the famous "battle" of Shrewsbury),—and Wroxeter, with its newly-discovered treasures, which supplied a rich treat for the concluding day of the congress, the 11th of August. Some of the topics brought under notice appear to have suggested the paper prepared by the Rev. R. W. Eyton, on "the Castles of Shropshire," read at one of the evening meetings, of which we subjoin a brief synopsis:—He expressed his conviction that castle-building was not the particular genius of the Normans, as some people imagined, nor were they properly called "feudal." Their existence was rather a symptom of weakness and internal dissension than of strength. The chronicles record but one Saxon fortress, Ethelfledas—Shropshire Castle, as it was called—which was built in the thirteenth century. The site of this castle was still to be observed, a mound at Oldbury in the vicinity of Bridgnorth. Earl Roger de Montgomery founded a castle at Shrewsbury, the fourth "Doomsday" castle. The writer went on to describe a number of castles and castellated residences on the Salopian borders—Quatford, Cleobury, Wem, Pulverbatch, Corsham, Kinnerley, Oswestry, Stokesay, Charlton, Apley, Wroxeter, &c. On the whole he showed that the period which gave birth to the above castles was the period when the contest for power lay chiefly between the crown and the aristocracy, and when the people merely appeared on the stage in the persons of a few individuals favoured by fortune, who had obtained wealth and purchased with it aristocratic privileges; and it was the policy of the crown to discourage castle-building except on the borders, where inroads might be made by the Welsh. Turning to the border castles which guarded the western portion of Shropshire against the inroads of the Welsh, he said they consisted of an inward and an outward chain. The outward chain consisted of the castles of Chirk, Whittington, Oswestry, Kinnerley, Alberbury, Overton, Corse, Montgomery, Sneyd, Bishop's Castle, Clun, Stapleton, Knighton, Moreton, and three others. The inner chain consisted of the castles of Whittington, Ellesmere, Middle, Ruyton, Shrawardine, Church Stretton, and Brampton Brian: altogether twenty-four. Certain of these were as old as the reign of Henry I., the rest were probably later. The writer then proceeded to give some particulars of each castle in the order in which they stand above, commencing with a short history of Shrewsbury, which was built in 1080, and tracing the date of their foundation and enumerating the successive owners, in most cases down to "Doomsday." He thought in all probability Sneyd Castle was a creation of the imagination; there was very slight proof of its existence, and it was believed to have been confounded with Montgomery Castle in some of the old records, where it was named with it as "the Castle of Sneyth and Montgomery."

ON THE TREATMENT OF SUBSERVIENT FEATURES AND ACCESSORIES EXHIBITED IN SOME LATELY ERECTED BUILDINGS.

MR. EDITOR.—In continuation of the observations I have already made, I now propose to offer some remarks upon the building in course of erection intended as a Library for the Society of the Middle Temple.

As regards the general proportion of the mass, as well as in many other respects, this building—speaking with reference more especially to the exterior—is pleasing. There is ample height, and good pitch of roof, and the north and south or end fronts are by no means uneffectively designed, that towards the river particularly. The entrance approach from what is called the Garden Court, adjoining the garden and west end of the old hall, is also well and conveniently managed. The principal points on which deprecatory remark appears to be called for are, first, the almost strict uniformity of design in the two sides, and the want of suffi-

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cient substantiality of expression in the base of the building as here exhibited; secondly, the size, and the mode adopted in the arrangement, of the chimneys; and thirdly, the character and proportions of the louvre or flèche, with, fourthly, the design of the lucarnes or roof perforations.

The first point, that of recurrent uniformity, or the "ditto repeated" principle, is one which we may see a very marked and studied disregard of in most of the best examples of Mediæval design, and it is to this that we are indebted for a number of very beautiful and telling effects in them. In the present instance this being apparently lost sight of, the oneness or perfect similarity in size and in the disposition of every window, according to the story in which it appears, and the constant recurrence of the same feature and detail, conveys far too closely the notion of relationship to the ordinary ideas of modern design and practice, to be wholly satisfactory. It is possible however that ancient architectural canon and revived correctness of professional taste in these matters, which now happily extensively exists, and should regulate these points, have been met and successfully opposed by adverse legal dictum; the result being unfortunately, as in most things equally contradictory to each other, a variance with the better practices shown in earlier times, and the more qualified judgment which dictated them.

The only difference in the exact resemblance of the two sides is that caused by the introduction of the tower staircase at the north-east angle. The upper windows in each are arch-headed, of three lights each, with tracery throughout of the same pattern. Below these there is a double range of square-headed windows, each also of three lights, and alike in the respective stories they light. The buttresses which separate these and form the bays are also counterparts of each other. The lower range of windows breaks into the plinth; and this brings me to the latter part of the first point I have noticed,—the want of substantial expression in this feature.

It might be considered that the lower portion of this building, by its subdivision internally into two stories, and the introduction of the necessary windows to accommodate this arrangement, is enough denuded of that breadth and solidity which should exist at this part in a structure of the kind; and it can hardly be questioned, I think, but that some counterpoise should have been provided for this. A good bold proportion of base-mould and subplinth carried up at some height would have helped to do this very largely, and the lower windows would have appeared less obtrusive in the deep recess of such projection than they now do in the plain thin plinth of about three inches advance only, which now finishes the lower part of the side walls. Why, at least, could not the base mouldings of the buttresses have been continued as a base through each bay? even this would have obviated the want of sufficient footing which is now so directly apparent here.

On the next point, the size and arrangement of the chimneys, it may be observed that they are far too small, in fact, out of proportion altogether with the building: they rise also in the plane of the parapet and from behind it, without any outward projection, according to the more common and picturesque, as well as practically advantageous methods, seen in ancient examples. How much the treatment of the chimney-stack as a prominent feature of their fronts, in distinction to excluding it, tends to the characteristic and pleasing effect of the same, may be seen in a number of old instances. Here, similarly considered and arranged, such would have conduced very materially and agreeably to do away with the sameness complained of, by breaking the straight face, and affording opportunity for varying the design of the side fronts. As it is, we have on the contrary, as in the other detail and features mentioned, two chimney-shafts on each side parapet, and a repetition of the same design, position, and treatment in the case of each two.

The third point is essentially a very interesting one. The louvre properly treated is one of the most appropriate and effective adjuncts of buildings of the type here exhibited: insufficiently studied, and improperly or disproportionately designed, it is often very unsightly. For example it is only requisite to refer to some of the very beautiful louvres or flèches of the continent—most of the earlier ones in this country, such as originally existed at Westminster, Eltham, Crosby Place, &c., have been unfortunately destroyed—and to contrast them with some of the modern or comparatively modern introductions of the kind. One of the latter remains immediately adjacent to the building we are noticing. It would be unfair to compare the louvre of the Library with that of the Hall, for the former may justly be considered to have more the legitimate character of such a feature than the latter; but it is very far from being what it should or might have been. Its proportion is too stunted, and the gradually aspiring arrangement and design of the best examples is lost sight of. The pyramidal roof rises much less than it should do, and the spring at the eaves is greatly too sudden and apparent. It also lacks the ornamentation and treatment of the leading, which in many specimens relieve the surface and vary the sky-line of this part.

Lastly, the roof perforations are treated as miniature dormers, —the French *lucarne*, or what are still called "lucomes" in our eastern counties,—correctly to be so treated only when performing their original and proper function of lighting an upper room, or. the corresponding *grenier* in a French roof. In the present case they are ventilating louvres or openings, and with a more direct reference to this purpose should have been so dealt with as to convey at once the idea of this their actual use and action to the observer. There are many examples of the proper mode of treating these in the continental roofs, all opposed to that here shown, which is applicable in strict propriety and exclusively to a different feature.

CENSOR.

WIDENING OF LONDON BRIDGE.

IT is now six years since the Select Committee sat to take evidence on and consider the subject of the metropolitan bridges (see p. 21, vol. xviii. of this Journal); yet in all the time that has intervened nothing has been done, if we except the commencement at Hungerford for the Charing-cross Railway, to meet in some measure the urgent wants of the public; while the danger and difficulty is increased and increasing every day.

A variety of noble projects were no doubt brought to the notice of the committee, an outline of each of which we have given in the volume alluded to; but the grandest—almost too great for even London—was Mr. J. Pym's "super-way," about 65 feet over the present thoroughfares. Great as it was, and extending over 8½ miles, we are of opinion some of it might have been, and might still be, beneficially adopted: for instance, the first division from the London-bridge Station to Fenchurch-street Station. Some of the other lines of Mr. Pym's project, viz., from the London-bridge Station to Waterloo Station and on to Westminster, are being superseded by railway; and while the Thames Esplanade and Embankment project is ripening it would be premature to renew the idea of an aerial transmission from Blackwall to St. Paul's and Charing-cross; but we think a very excellent and paying extension from Fenchurch-street Station might be made westward, diverging greatly to the north of the line proposed by Mr. Pym, viz., to proceed from Fenchurch-street to the proposed central Farringdon-street Station, then close by St. Martin's-le-grand, with intermediate or secondary stations at both the Bank of England and the General Post Office. From Farringdon-street it might run almost direct to the corner of Tottenham-court-road and Oxford-street, intermediate or secondary stations being provided at Chancery-lane and Great Queen-street, between which it would run over Lincoln's-inn-fields. It will be thus seen that, the whole distance being divided into six parts, it might be so arranged that only alternate trains should stop at the intermediate stations which should bear the same colour; thus, Chancery-lane and the Bank stations might be blue, and Queen-street and the Post Office stations yellow; every train to stop at Farringdon-street and Fenchurch-street.

It may be asked, What has this east and west line to do with crossing the Thames? The reply is, that it would not only relieve the Strand, Fleet-street, and London Bridge of an immensity of the omnibus and cab traffic, now so uncertain, as regards time, to catch the London-bridge Station trains, but it would relieve New Oxford-street, and Holborn-hill and Skinner-street, of the whole of the omnibus traffic, and the cruelty to animals attached to them daily and hourly practised thereon: thus getting rid of two of the greatest metropolitan difficulties,—Holborn-hill, and the crossing of the Thames to the London-bridge general railway station.

We now come back to the question as to the propriety of widening London Bridge, which we are decidedly in favour of; for if Mr. Plew's design for a bridge at St. Paul's (so-called) was ready to be executed, the difficulty of forming a northern approach

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by the widening of Old Change, &c., now that New Cannon-street has been built across the open once available, would raise an insuperable objection to it; while an excellent road could be carried from the level of Blackfriars Bridge and proposed esplanade there, at that level over the wharf, on piers, (the difference of level being 22 feet between the bridge-road and wharf-road), then up across the east end of Earl-street, also over it, and at the very easy inclination of about 1 in 80 reach the level and open area of Doctor's-commons in front of the Deanery, from which the purchase of a house or part would open out to St. Paul's; and were not the superb view of the building to be thus obtained worth the difference of purchase, egress could be easily made sufficient by enlarging the existing archway to three or four times its present breadth, and twice the height it now is.

Before entering on the immediate question of widening the bridge, it may be desirable to refer to the proposed relief of the traffic by crossing lower down the river. Mr. Page's very elegant project of a suspension bridge from Tower-hill, 70 feet high, so as to avoid the shipping, from the necessary length of the approach from the Surrey side, and the general position, we fear would not be as useful as it would be expensive and ornamental.

Should the London-bridge and Fenchurch-street Stations not be connected by the super-way alluded to, no doubt it would be desirable, and a great relief to the traffic, to see the so-long-useless Tunnel appropriated to railway purposes, for which we think there is much facility. The line of exit at the north-west end being produced and kept sufficiently low for that length, would pass under the narrow junction of the east and west London Docks, from whence a curve of half-mile radius would carry it under Wellclose-square (where an opening to the surface might be preserved), to a position parallel with and adjoining Fenchurch-street Station: the ascent from the passage under the dock-junction to a platform not unreasonably sunk below the street, need not be greater than is worked into many stations,—say 1 in 70.

Lastly, although we agree with Mr. Tite, that the light parapet that *might*, we will not say *must*, be substituted, were the footways to be supported on brackets or cantilevers, "would interfere with the architectural propriety of the bridge," still we are inclined to believe that a very elegant and suitable widening could be effected by which the entire breadth of the present footways could be given to the carriage-way, while providing new footways not less than 12 feet wide, and even greatly ornamenting the bridge, at perhaps one-twentieth part of what a new bridge anywhere across the Thames in London would cost, not to speak of the necessary outlay on approaches.

If there be a necessity for further securing London Bridge from the scour of the ebb-tide, according to the evidence of Mr. G. R. Burnell (see p. 26, vol. xix. of this Journal), the present opportunity ought not to be lost. Our view is that on an advisable extension of the piling above and below each pier, adequate foundations could be laid for coupled columns, of a character, suppose Grecian-Doric (without base), and suited to the general solidity of the structure. From the entablature curved cast-iron ribs, coinciding exactly with the lines of the arches, might be sprung, and being kept as high as well-raised footways would admit, and as light as would be amply sufficient to support the outer edge of the footways across such spans, we are of opinion that the thing could be effected in that manner, so as in no way to deteriorate from the general effect of the bridge, if it would not improve it.

We would give, as we have said, the whole of the breadth of the present footways to the now insufficient carriageway of the bridge, which acquired space might be appropriated altogether to light and fast-going vehicles; but the whole breadth of the base of the present solid parapet we would reserve as an efficient foundation or bed for the unusually heavy granite heading or curb we would propose that the new footways should have. There could be no objection to the weight, while its inertia and bond on its adequate bed would prevent a disturbance of the footway from the passing of even the heaviest vehicles.

But the new parapet, or combination of parapet and railing, need not be of that flimsy description anticipated, so as to have, in the words of Mr. Tite, "an unfortunate effect." We believe that a very elegant and massive-looking, light yet strong, protection to passengers, could be contrived and executed,—solid-looking, like a plinth, for probably 18 inches in height from its bed, to be surmounted by a massive flat balustrade, of at least 1 or 1½ inch thick cast-iron, pierced with openings about the same breadth of the rails or part remaining, and circular-headed. This, surmounted by a sufficiently wide and bold cornice or top-rail to give stability, divided as architectural taste might suggest by panelled pilasters, we are of opinion, could be made to produce a very good effect; and the castings for the spandrels being also panelled, would increase the general finished appearance of what, after all, could be viewed but as an addition, however necessary, efficient and inoffensive.

The cast-iron ribs coinciding with the present arches—capping them, as it were—could be steadied and strengthened by brackets, but not extending down so as to injure the effect of the bridge, as they would do if there were no cast-iron ribs; and the whole could be stayed and held together by chain-bars passing from side to side of the bridge under the pavement, as adopted successfully in other places. But we are of opinion that brackets alone would not sufficiently support footways of the breadth we have proposed, or of a breadth to repay the trouble and expense of interfering with London Bridge.

Should strong objections be raised to the extension of foundation at either end of the piers, as we have suggested, it will be found on examination that there really exists about 6 feet of solid bearing at present on the ends of the piers, over which the seated recesses are extended. With such a base, brackets (tied through the roadway as stated by chain-bars) could be made quite sufficient, four for each pier, from which very light segments only would be required, to act chiefly as ties to the line of corbels or brackets, the main support being by a single line of adequately heavy segments, resting on and springing from the pier extensions now occupied by the recesses. In conclusion, if the bridge be not widened 21 feet, somewhat in either of the modes suggested, it would be far better to let it alone, and to struggle on by throwing Southwark Bridge open to the public.

STREET IMPROVEMENTS OF LONDON.

Commencing as our starting point at Northumberland-house, we find the two blocks, comprising five large shops and houses extending to Craven-street, now nearly completed. These structures are of the style usually adopted in our modern street architecture—Italian: they are five stories in height, and are faced with brick, having Portland cement dressings to the windows, and are crowned by a large cornice and parapet of the same material. They have been erected with remarkable rapidity by Messrs. Holland and Hannen, builders, from the designs of Mr. Bushell, architect.

Beyond the corner of Craven-street, and stretching south, Mr. Simpson, the proprietor of the Craven-hotel, has made and has in progress extensive alterations in his establishment, from the designs of Messrs. Banks and Barry. The most notable feature of the interior is a coffee-room of very elegant and novel design: this room is 50 ft. 4 in. long by 22 wide, and about 16 feet high; it has a recess at its western end, and on its northern side is a series of Ionic columns with capitals of chaste design. The ceiling is divided into six panels by plain mouldings; the walls are also panelled in Parian cement, which is of extreme hardness, and resembles white marble. The room is lighted at night by twenty-two elegant chandeliers. Messrs. Lucas Brothers are the contractors.

The new building to be erected at the corner of Villiers-street, from the designs of Mr. John Barnett, architect, is to be faced with red brick, with Portland cement dressings to the windows and doorways. The principal cornice at the eaves is to be of the same material, and will have a similar section and range precisely with that of the adjoining edifice recently completed for Messrs. Elliott Brothers, of which Mr. Maclure was the architect.

The next structure deserving attention is that now in progress on the northern side of the Lyceum Theatre in Wellington-street, having a return side in Exeter-street. The building is from the designs of Mr. Withers, architect, and is intended for offices, &c. The façades are being constructed of coloured brick in ornamental patterns, with Ancaster stone dressings; and the whole when completed will form a striking contrast to the painted compo theatre against which it abuts. The principal front of this new building, in Wellington-street, is 60 feet in length by a depth of 50 feet, and an average height of 40 feet, the curb line of the footpath being on an incline. The construction and arrangements of this edifice are exceedingly good, the floors being fire-

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proof on Fox, Barrett and Co.'s patented principle. The ground floor is supported on massive brick piers and arches, and the first floor on a series of iron columns, 15 feet in height, with moulded caps and bases, cast by Mr. Frasi. The ground floor is to be used as a show-room and offices, and the first floor as a picture gallery, to be lighted from the roof, which is very peculiar in its construction, and will be divided into panels, with excellent provision for ventilation. The general elevation of the building consists of a Mezzanine basement, on which the ground and first floors are composed of a series of semicircular-headed arches, of red, white, and yellow bricks judiciously intermingled. The piers between the windows are also of brick, and on their faces are pilasters, the cappings and bases of which are of moulded Ancaster stone. The spandrils between the arches are of white and red brick in pattern, and over each pier there are circular insertions of green marble surrounded with mouldings of stone. The whole of the window-sills and string-courses are of Ancaster stone: the cornice at the eaves is formed of stone trusses, with panels of coloured brick between them The principal entrance is of characteristic design. Mr. E. W. Sims is the clerk of the works under the supervision of the architect, and Mr. Rowland is the builder. The Ancaster stone employed in this building, now we understand first introduced in London, is a most excellent material, being very durable, of uniform texture, and not so cold in colour as Portland stone. The noted church at Boston, Lincolnshire, was built of stone from the Ancaster quarries.

Opposite to St. Dunstan's church, Fleet-street, a building is in progress for the Promoter Life Assurance Company: its elevation though somewhat narrow, will furnish a favourable example of Renaissance architecture, with a considerable amount of embellishment in Portland stone, granite, and marble. The front is in three stories above the level of the footpath. Over the cornice at the eaves, in the roof, there are characteristic dormer windows lighting the attics. The building has a depth of 50 feet. The basement contains the porter's living and bed rooms, strong room, lavatories, water-closets, &c., the whole being floored with York paving. On the ground floor are the public office and secretary's room; on the first floor, the board-room and medical officer's room; the second floor will be occupied by a clerk's parlour and bed-rooms; and on the third floor is planned a kitchen, scullery, general closet, pantry, and servant's bed-rooms. The whole of the plain facings in the principal front have been executed in Portland stone. The ground floor is composed of three-quarter polished granite columns on stone piers, that divide the windows and doors from each other. On the first floor the blocks between the windows, which are arched, are of Portland stone inlaid with Peterhead granite, their spandrels being richly carved in foliage. The second floor windows are to a certain extent square-headed, but rounded at the angles, and divided by pillars having on their faces three-quarter round red granite shafts highly polished, over which there is an effective cornice composed of trusses in pairs supporting the entablature, having in the frieze red granite panels. One peculiarity of the elevation is that from the level of the second floor there is a projection, supported by stone corbels, and surmounted by the central dormer. The roof is of the Mansard type, covered with slates of diversified patterns. Mr. W. G. Bartleet is the architect; Mr. Willson the builder. The carvings in stone, many of which are highly elaborate, have been admirably executed by Mr. James Forsyth.

On the western side of Chancery-lane, at its Fleet-street end, two large houses and shops have just been erected, of Italian character, from the designs of Mr. Todd, architect. The buildings have together a frontage of 54 feet, and a depth of 55 feet. They contain no features worthy of special comment.

At the south-eastern corner of the Crescent, New Bridge-street, Blackfriars, a large structure has just been erected, as offices for the Eagle Insurance Company. The plan of the building is somewhat novel, necessitated by its elevation on the Crescent side being of course slightly curved, while the flank front is straight. The elevations are Italian, and present an elaborate display of moulded work and enrichments, produced with a considerable amount of effect. The principal entrance is formed of a close portico, composed of double pilasters, with leafage capitals at the external angles. Above this level is a string-course, embellished by dentils and other ornaments. The second-floor windows, comprising eight in both the elevations, are all angular-headed, having in their tympanums shields and foliage. The dressings of the windows round the two upper stories are of a plainer description, and between the third and fourth range there is a cornice, the corona of which is supported by enriched cantilevers; above there is a cornice ornamented with foliage frieze springing from shells, surmounted by a plain parapet. The architect is Mr. Henry Curry. Mr. Jas. Tolmie, architectural sculptor, has supplied the models required; Messrs. Lawrence, Brothers, are the general contractors; and Mr. Miller is the clerk of works.

On the western side of New Bridge-street, and abutting against the northern end of Messrs. Spicer's property, which was renovated some time since, a large block has been rebuilt on an improved plan, from the designs of Mr. Sydney Smirke, R.A. The block now forms a range uniform in design from Tudor-street to William-street, and is a great improvement, bearing out our often expressed opinion that street architecture to be really good should be uniform in design from cross-street to cross-street, as is the case in this instance. One feature of the elevation is a balcony projected from stone cantilevers and surmounted with an open railing, the whole length of the façades, to correspond with the block at the Tudor-street end. Messrs. Piper and Sons are the builders.

A huge five-story warehouse has just been completed at the south-eastern end of St. Paul's-churchyard, and the western extremity of Cannon-street West. This building effectually obstructs the only good view of the finest building of which we can boast in London. Its erection there is greatly to be regretted. The Institute of British Architects protested against the erection of the building referred to, but in vain.

Of a block of building in Cheapside, forming part of Ironmonger-lane, we shall only remark that it is satisfactory to find that no professional architect was engaged to furnish the design, which may be described as in the "carpenter's chamfered" style, from its numerous chamfered angles. As to the materials employed (good brick and stone) there is no fault to find; but it is surely a lamentable waste of good stuff, when applied, as in this case, to the most villainous forms that could well be conceived.

A noble example of warehouse architecture has been erected in Aldermanbury, with a considerable degree of ornate splendour externally. It is Italian in style, and its constructive arrangements are excellent. The area on which it stands is 98 feet by 69 feet. The basement is exceedingly spacious, and is floored with Seyssel asphalte. The walls of the ground floor are lined throughout with match-boarding, in order to keep the goods perfectly dry. At the rear is a large show-room 65 feet by 40 feet, with a gallery around it for the display of goods, 10 feet in projection, lighted from the north, which is advisable in the display of certain fabrics. The ceiling of this show-room is embellished in decorative plaster-work, under the direction of Mr. Manning. The front of the gallery is protected by iron railing, divided by oaken moulded pedestals 10 feet apart, and an oak hand-rail. The second floor of the building is arranged as a residence, the third as bed-rooms, and the fourth having a kitchen, scullery, housekeeper's room, butler's room, lavatories, closets, and all necessary conveniences. A lift-engine is provided, worked by hydraulic pressure. The principal front of the building is of brick and stone, its lower portion containing a rich frieze of foliage in its cornice. Mr. Edmund Woodthorpe is the architect; Messrs. Brass and Co., the contractors. The carvings have been well executed by Mr. Daymond.

REVIEWS.

Construction of the Great Victoria Bridge in Canada. By James Hodges, Engineer to Messrs. Peto, Brassey, and Betts, Contractors. London: John Weale.

We have rarely had a more agreeable task than has been furnished us by an examination of this really magnificent volume, describing the Victoria Bridge, from the pen of Mr. Hodges, the actuary in Canada on that great work for the eminent firm of Messrs. Peto, Brassey, and Betts, the contractors who executed it. The volume and the very beautiful plates which accompany it have evidently been prepared at an immense cost, but which has secured the accuracy and excellence of the whole: the numerous woodcuts, or diagrams as they are modestly called, are admirable.

The Grand Trunk Railway of Canada traverses British North America for 1200 miles, from the ports of the Atlantic to the prairies of the distant west, and opens up a traffic and means of

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intercourse for the inhabitants of the wonderful valley through which it passes, hitherto shut up for six out of every twelve months;—one of its greatest advantages may be, as stated, associating "together the British dependencies in North America."

The Canadians *were* indebted for their prosperity and means of communication to the St. Lawrence and the great inland lakes, and the Welland Canal only admitting vessels of 300 tons, although ships of 700 or 800 tons could go as far as Lake Ontario, transhipment became necessary for the produce coming from the great western cities, and from Lakes Erie, Huron, Michigan, and Superior. The rapid growth of these cities and districts thus required the railway, which effects for them a communication with Europe 600 miles shorter than any other that could be made between the continents: "its whole course can be traversed without change of vehicles, and the line is open for traffic irrespective of seasons." Canada is mainly indebted for this means of communication to the efforts of the Hon. Francis Hicks, now governor of Barbadoes, and the Hon. John Ross, speaker of the House of Assembly, "the first as head of the government, the second as president of the corporation."

Inasmuch as from the head of Lake Superior to the Atlantic Ocean, there was no bridge across the St. Lawrence for 1500 miles, excepting at Niagara gorge, it was obvious, even after the construction of the railway, that the key to the province would be in other hands if the railway did not span the river; hence the necessity for the Victoria Bridge. Only eight years ago, at the request of the provincial government, an examination of the country was made, with a view to the development of a system of railways for the colony, by Messrs. Peto, Brassey, and Betts; Mr. W. Jackson, and Mr. A. M. Ross, C.E., subsequently assisting: and from the information thus obtained the Grand Trunk Railway, as a complete system, was brought before the British public, under the influence of Mr. Thomas Baring, M.P., and Mr. G. C. Glynn, M.P.; but as early as 1846 the Hon. John Young, of Montreal, had suggested the practicability and necessity for a bridge across the St. Lawrence at Montreal, and he succeeded in obtaining surveys and reports upon the subject from several eminent engineers,—Mr. Morton, 1846; Mr. Gay, 1847; Mr. Growski, 1849, and Mr. J. C. Keepe in 1851,—by the help of which, and the information he obtained on the spot, "Mr. Ross, on his return to England, designed the structure upon the principle on which it is carrried out, and upon which the provisional contract was taken, and who, as engineer-in-chief of the Grand Trunk Railway, afterwards resided in Canada until

Fig. 1.

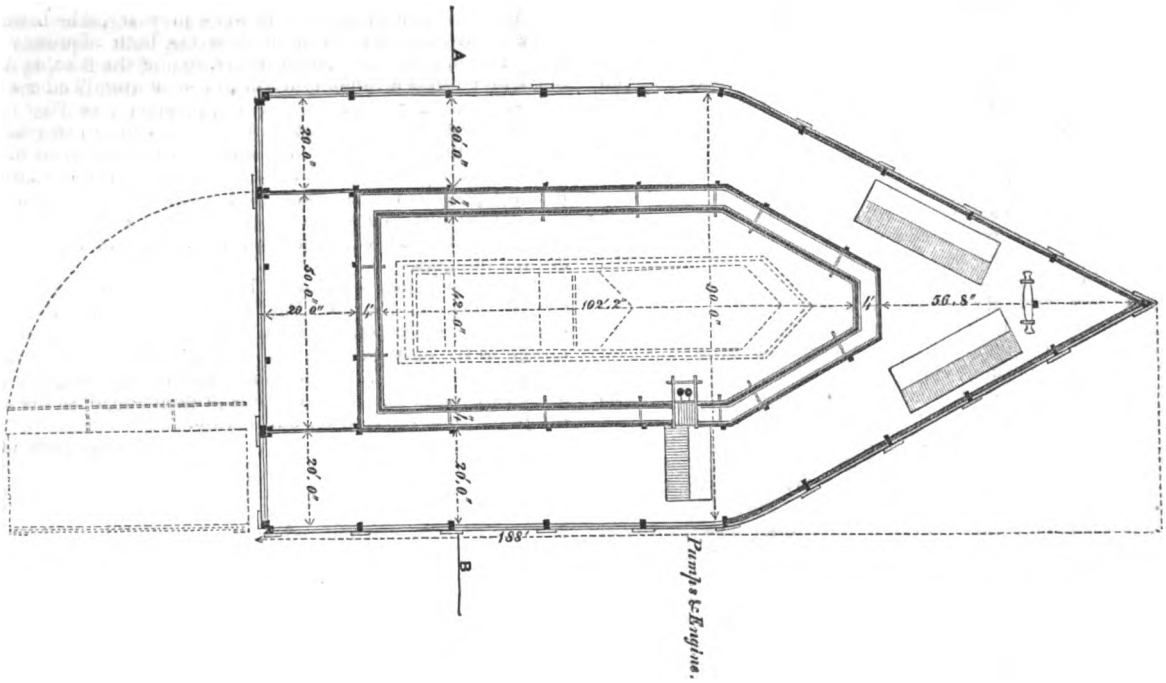
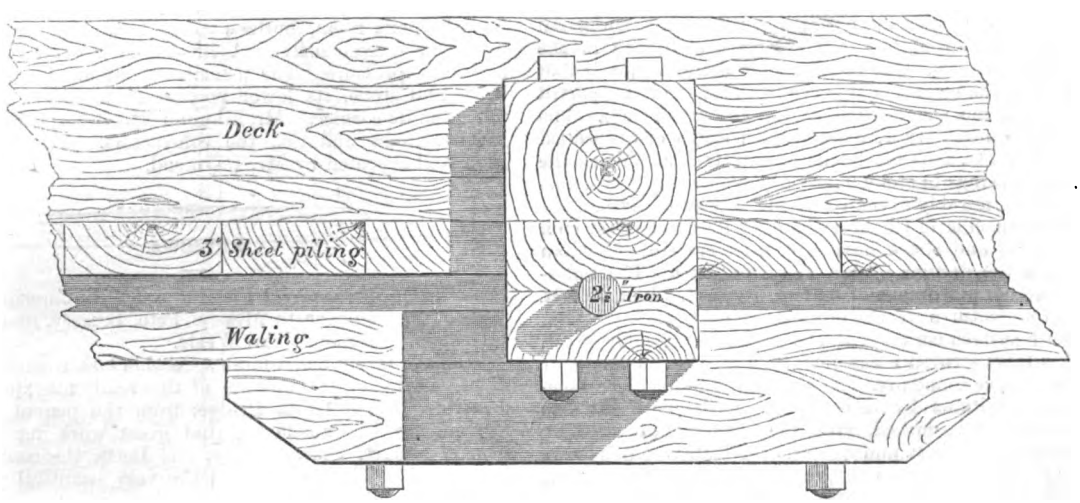


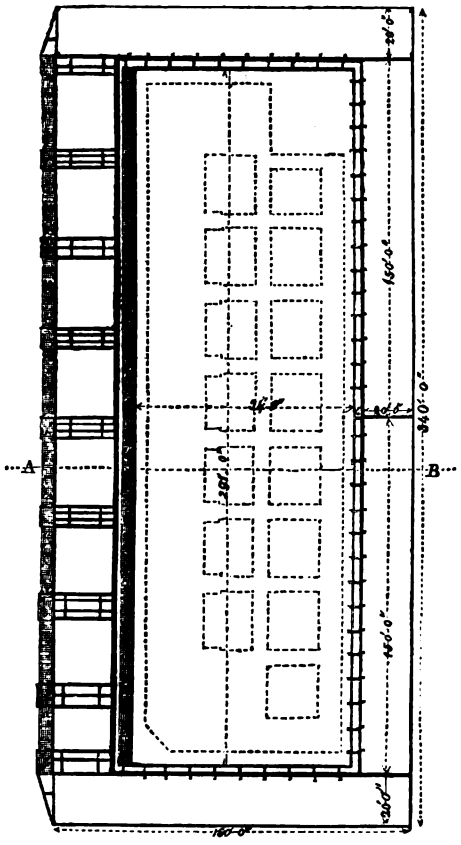
Fig. 2.



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the works were completed." We must here supply what from the context appears to have been an inadvertent omission on the part of Mr. Hodges, viz., that the design of the tubular bridge was altogether the late Mr. Stephenson's, who also advocated

Fig. 3.



and succeeded in effecting the adoption of stone instead of timber ice-breakers; for when Mr. Ross, after his visit to England, probably consulting with those here most capable of advising, considered that Mr. Stephenson's tubular girder was peculiarly adapted to the crossing of the St. Lawrence by railway, we find that on his return to Canada, and upon the inauguration of the company, the great importance of this work decided the board of directors to consult Mr. Stephenson, whose high authority and sanction it was deemed of great importance to obtain, and who, after examining the information and designs laid before him by Mr. Ross, signified his approval of them, and undertook jointly with him the responsibility of engineer to the bridge. In the summer of 1853, Mr. Stephenson purposely visited Canada to view the site of the bridge, and, conjointly with Mr. Ross, decided upon the structure as it now stands.

The site of the bridge is at the lower end of a small lake, called La Prairie Basin, about one mile above the entrance to the Lachine Canal, at the west end of Montreal Harbour, the river being there a mile and three-quarters in breadth; but the lake is extremely shallow, and incommoded by boulders, and was only to be navigable, except in the main channels, for craft drawing 18 inches to 2 feet of water. The bed of the river at the point selected is fortunately solid rock, but like the lake, incommoded not only by boulders, but the bank called the Middle Shoal, which greatly increased the difficulty of construction and the conveyance of materials by boat, with a current running seven or eight miles an hour. The scenery, if not grand, is represented as interesting, agreeable, and English; the well-built town rising up at the one side, and the rather flat margin opposite being backed by the blue hills in the distance.

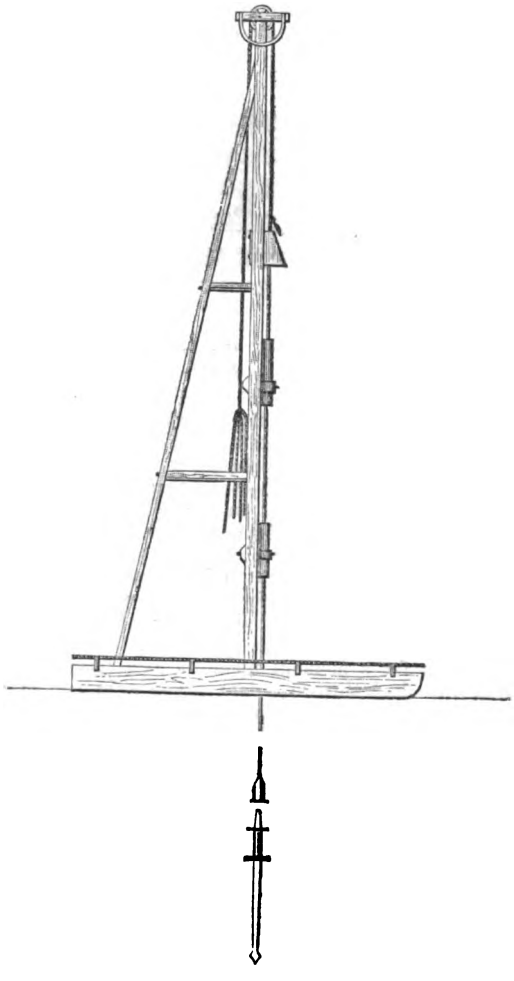
Chapter 3 is devoted to the subject of "the Ice," particulars respecting which have already been given in our Journal (p. 157 *ante*). Chapter 4 opens with an outline of the proceedings taken in order to obtain a proper stone for the structure. A stone*

* A dense blue limestone, see *ante* page 157.

having been determined on, the meeting with the old Indian chiefs representing the tribes who were in possession of the quarry, is extremely interesting; and the shooting of the Lachine Rapids in a small steamer, with an Indian as pilot, is worthy of a place in one of Cooper's novels. In the words of Mr. Hogan's prize essay on Canada, from which a few lines of description are quoted in a note (p. 11), "it is one of the sublime experiences that can never be forgotten."

After the description of the extremely suitable barges and tug-steamers with light draught of water, built expressly for the work, Chapter 5 opens with a description of the floating dams or caissons, 180 feet by 90 feet, removable at winter, from the impossibility of anything remaining in the river (see Fig. 1). The securing and rendering watertight those floating cofferdams was effected by a species of piling—which we have alluded to in this Journal (*ante* p. 281), in a paper on the Thames, and there called the *apron* or stockade coffer—with in addition a dozen 2½-inch bars (see Fig. 2), steeled and sunk 2 feet in the rock to prevent the almost possibility of their being disturbed or removed. The abutments were similarly provided for (see Fig. 3); but these sliding or stockade main piles afforded not only the ordinary facility of being pushed down to the rocky bed of the river, but when secured there in the manner described, the whole caisson could be lowered in connection with and held in place by them. When lowered until some part rested on the bottom or on a boulder, these main piles were then bolted to the sides of the dam, or coffer, and the scuttles opened to throw the whole weight upon those piles, which thus acted admirably as legs,

Fig. 4.



just as stays are put to keep sharp-built vessels upright when necessarily taking the ground.

A desire for brevity has, no doubt, compelled the omission of detail in many parts that, in connection with so great a work and so prodigious a current, it would have been useful to many

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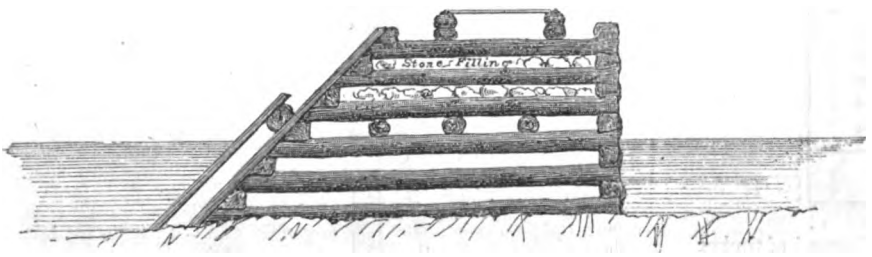
to have inserted. Thus we must assume that "the sheet piling necessary to form the puddle chambers" was forced to the bed of the river, "guided by the walings" provided for that purpose; but with even a pressure of 10 or 12 feet of water, once the pumps were set to work inside the coffer, it might have been well to have clearly stated how the puddling was got in without a large portion being carried away. The toes of the piles were however fitted to the rock by being struck down, and, on lifting, the part pressed on was cut away, by which a better fit was effected, and much of the difficulty alluded to removed.

In the building of these immense and, of course, unwieldy hollow square vessels or coffers, excellent forethought was exhibited in the construction of them on the river bank 10 feet over the level of the ground, in order to give the "ways" sufficient fall to effect the launching without difficulty, although necessarily built at such a distance from the river as to insure their safety from the shoving of the ice.

The mode of operation in forming a level road over the ice, although almost peculiar to the position, is interesting, particularly as showing the very great advantage the "ice-bridge" afforded for the setting out of the work, and the marking of the centre for every pier by an iron drill or pin, "5 feet long, 4 inches diameter, bored in to the bed of the river 3 ft. 6 in. to 4 feet or till the cross-bar, to which was attached buoys, touched." These drills, the small ringing engine for driving them, and the long rod and square socket for attaching and holding them, are shown in Fig. 4.

Anchorage with a rocky bottom being impracticable, considerable ingenuity and forethought were also exhibited in the contrivance and arrangement for loaded crib moorings, planned to be only a foot above the summer level of the river, so that the winter ice might pass over without injuring them. The placing of the crib-coffers broadside on, for the abutments to be erected in, with a current even by the shore of five miles per hour, were so difficult that "the two end scows only were moored and scuttled, after which small skeleton cribs were framed, and sunk 25 feet apart, in the line of the up-stream side of the dam. Upon a longitudinal timber laid on these, sloping planking was placed at an angle of about 45 degrees, the lower end resting on the bed of the river," by which means

Fig. 5.

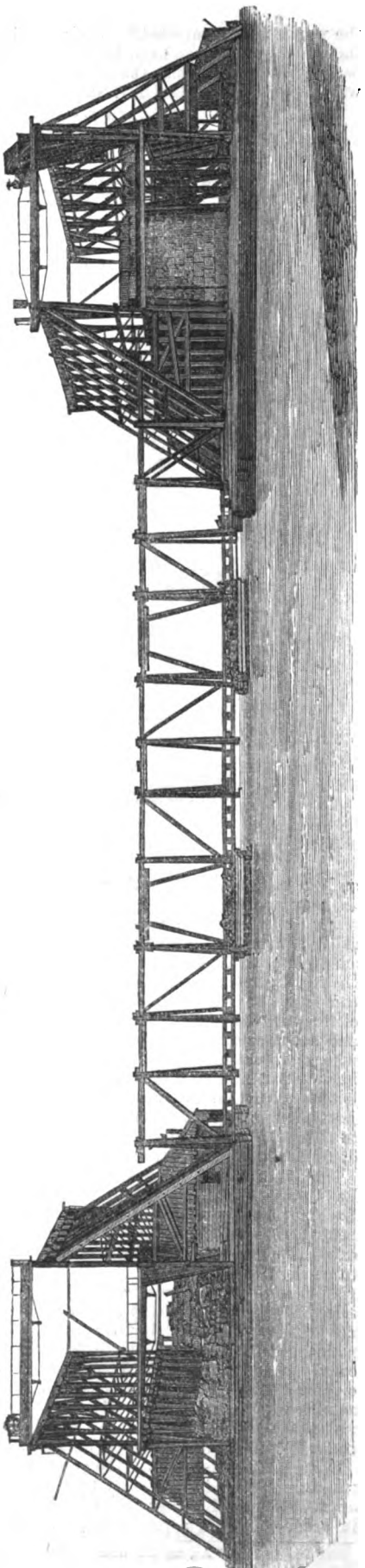


"quiet water was obtained across the whole of the space to be occupied by the abutment." When the water fell from flood-level, these abutments being scarcely approachable from the obstruction of boulders and the shallowness of the water, a tramway was fixed (as shown in Fig. 5) on pieces of skeleton crib-work, which, with the connecting and sloping planking, was buried in the embankment, which was effected in quiet water by the protection of the sloping planking, as already described in connection with the dam. A page of excellent practical information follows on crib-works, but suited to timber countries only. An interesting exemplification of the "shoving" power of the ice is added, moving piers of 150 tons weight down the Ottawa at Vaudreuil Bridge.

Floating dams, however excellent and worthy of consideration and adoption in all places suited to them, were found to be so difficult to navigate, from the great rapidity of the current, the obstruction of boulders, and the impossibility of procuring skilled labour to manage them, that the province may be said to have been thrown for a moment upon its own tried resources. Messrs. Brown and Watson, who had thrown a dam across a branch of the St. Lawrence, at the head of the Coteau Rapids, in a very strong current, undertook to construct two of the dams, Nos. 5 and 6, of crib-work, in the manner usually adopted in Canada. The detail of the difficulties these sub-contractors had to encounter, although very instructive, want of space will not admit of our quoting at length. It may, however, be briefly stated, that after having constructed portions about 40 feet long each of the crib-work, in the still-water near the entrance to the Lachine Canal, it was found impossible to tow them to the intended site, even although two steamers were employed for the purpose, the portions of framing being literally torn to pieces.

A very interesting experiment was then tried; the crib-work was put together at Lake St. Louis, and brought by Indians down the Lachine Rapids, at the foot of which, in La Prairie Basin, a steamer awaited them, but it was found impracticable to arrest the progress of such a mass in so strong a current. Finally, the material was taken in barges to the site of the dam, and the framing commenced immediately behind the moorings; when with much exertion it was completed, sunk, and well loaded with stone. A footing being at last secured in this manner, the formation of the remainder of the cribs for this dam was more easily effected.

Fig. 6.



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Strikes, sickness, and the demand for excessive wages, now caused great delay, and much of the temporary work that could be neither removed nor adequately protected, was carried either partly or altogether away on the breaking up of the ice in the following spring (1855). Plate 1 exhibits the state of the work at that period.

On the south side, the river being shallow, and the current not more than two miles per hour, the crib-work for the dams for the south abutment was constructed with very little trouble; the materials were conveyed to the work by means of a tramway laid upon cribs, constructed in the same manner as those used for the northern abutment. At the close of the season the masonry of this south abutment was 2 ft. 6 in. above the summer level of the river. For its details it is rather to be regretted we are referred to the plates only.

The stone for this abutment and many of the piers at the south side was obtained from La Motte Island in Lake Champlain, brought 40 miles by barges and 19 by the Champlain railway. It appears to have been of the same (hard blue lime) stone as that brought from Point Claire, but of a finer quality.

We are at present unable to give a representation of Mr. Chaffey's Steam Traveller, which "handled the whole of the stone for the south side of the river." It will be seen in Plate 6 of the work under consideration; it ran upon gawn-trees 1300 feet in length, 20 feet in height, and had a span of 60 feet.

It is worthy of remark that at the commencement of the works in 1856, the most difficult portions of the dams to be freed from leakage (No. 3 pier) was where the rock was more or less covered with clay, boulders, gravel, or sand, through which the water seemed to percolate; and the whole puddle-chamber, 3 ft. 6 in. in breadth, was nearly filled with sheet-piles, breaking joint on each other, before the staunching could be effected. No. 4 pier presented no difficulty, the water being shallow and the ground solid, overlaying the rock to the depth of 12 feet, without any clay or running sand; but as no craft except canoes or small boats could approach, from the number of boulders surrounding it, a temporary bridge upon scows was erected across the opening between the piers 3 and 4, to keep up the communication, and supply the materials required—as shown in Fig. 6.

To comprehend all the difficulties that had to be contended against and were successfully overcome, such as leakages through the rock itself, would require a careful perusal of Mr. Hodges' valuable work. It is to be hoped that in a second edition or a supplement some matters may be added which appear desirable on a review of the whole of the letterpress that accompanies the beautiful engravings. What has been done will form a very elegant, instructive, and ornamental addition to the civil engineer or architect's library. We shall resume our notice of this work in our next.

A Rudimentary Treatise on Clocks and Watches, and Bells; with a full Account of the Westminster Clock and Bells.. By E. B. Denison, M.A., Q.C. Fourth edition, re-written and enlarged.—London: John Weale. pp. 434. [Second Notice.]

Copy of Reports on the Condition of the Great Bell of the New Palace of Westminster. Ordered by the House of Commons to be printed, August 1860.

It remains to consider those portions of Mr. Denison's manual which treat of bells, and relate the history of the Westminster Clock and Bells, the portion relating to clocks having been noticed in our last.

It is not very easy to make any extracts which will give a clear idea of the interesting chapter on bells, or to give a good account of it without extracts. The weight and thickness proper for bells, their shape, the number of bells in a peal, the composition of the metal, the mode of moulding and casting—the arrangements for hanging, and the weights of the most celebrated bells in Europe, are among the principal topics touched upon. These are treated briefly but clearly; a great deal of information is pressed into a small compass; and although there are from time to time statements of the writer's personal opinion, given in a way that ignores the possibility of some different opinion being the correct one, there is quite enough on the subject to make it highly desirable that every person who has or expects to have anything to do with bells should see the volume.

Mr. Denison is a great advocate for the weight of metal in bells being considerable, on account of the tone they give out being so much finer the greater the mass. After referring to the proportion the various bells in a peal should bear to one another, the author continues as follows:

"But we have still to ascertain what is the proper weight for any given size or note. From the practice of some of the modern bell-founders you might suppose that it may be almost any weight you please, at least within very wide limits, as one sees bells of about half the weight of old ones, and yet of the same note; and then people are surprised that they sound worse.

Postponing for the present the consideration of bells to ring in peals, anyone who takes the trouble to compare the weights and the cubes of the diameters in the list of the principal large bells of Europe at the end of this book, will see that the bell-founders of all ages and countries have agreed in fixing rather narrow limits for the variations of weight in proportion to the diameter of their bells. And this is by no means from any blind following of each other; for there is a good deal of variety in the shape and distribution of thickness over the different parts of the bell, although it all ends in this near agreement of the proportions of weight and size; which would be nearer still, but for the foreign bells (except the Russian) being taller than most of ours. . . . . .

There is a fulness and softness in the sound of a thick bell which a thin one never has. The old bell-founders evidently knew what the modern ones do not choose to believe, or more probably do not care for, so long as they get paid for their bells—that it is a law of nature that a given weight of bell-metal is only capable of sounding a very narrow range of notes with good effect; and if you will infringe that law, and make your bells thinner for the sake of getting deeper notes out of them, you are as certain as usual in fighting with the laws of nature, to pay for it by a more than equivalent loss in the quality of the tone.

And it happens that this loss is even greater now than it would have been a century ago. For it is a well-known fact, and the experiments made for the Westminster bells confirmed it, that the copper of modern days is different from the old copper in some way that analysis does not indicate—less tough in working, capable of holding less tin without becoming too brittle, and apparently incapable of a certain softness of sound which even thin old bells sometimes have, but thin new ones never.

Before I leave this part of the subject I will give a short table which may be convenient to persons who want to know, without the trouble of calculation, of what weights and sizes the leading, *i.e.* the largest bells of a peal ought to be, according to this scale, which ancient and now also modern experience proves to be the thinnest that you can use without sacrifice of the quality of the tone, and therefore of the pleasure which the bells are meant to give to those who listen to them. And as a peal of bells is a luxury, and not a necessary of life, it does seem to me astonishing that people will go on raising large subscriptions for them without taking the least trouble to ascertain that they get what is really the best thing for their money, and forgetting that you pay for the same weight of metal whether the bells are thick or thin, only in one case you get them of the right notes for their weight, and in the other case of wrong, and so make the bells bad instead of good."

Mr. Denison favours the old adopted form for bells, not upon any theoretical grounds, but, as he says, from experience of its superiority to various other shapes tried against it. There is of course no difficulty in hitting exactly upon the form employed at any past time when bells were cast that are still in existence, but the same facility does not exist for ascertaining the chemical composition of those bells. Bell metal is, it appears, a combination of tin and copper, in proportions stated to vary between that of 3 of tin to 1 of copper, and 4 of tin to 1 of copper; and the composition prescribed for the Westminster bell was 22 of tin to 7 of copper, though Mr. Denison now proposes as advisable a deviation which would give 13 parts of tin to 4 of copper, in order that the proportions should agree with what are called the chemical equivalents or atomic weights of the two metals, which are, copper 32, tin 59. It would be a remarkable and interesting fact, if fairly established by experiment, that a composition of this nature has a tendency to become much more homogeneous than any other mixture, but the evidence upon which the supposition rests does not appear quite conclusive; it is thus stated:

"Lord Rosse made his great speculum on this principle, of 4 atoms of copper to 1 of tin (Cu_4 Sn), or in the proportion of 128 to 59 by weight; and it is said that a very slight deviation from it runs great risk of spoiling a speculum. I am told by persons who have made experiments both in that and other alloys, and some instances of it are given in books, that the combinations which are definite multiples of the atomic weights are less liable than others to separate or become unhomogeneous in casting, like Mr. Mears's bell, and that they are better in other respects: certainly the difference between the appearance of the fracture of the atomic speculum metal, and of other metal very slightly deviating from it, is remarkable."

A great deal on the subject of bell hanging and ringing, which we should like to notice, must be passed over for the sake of refer-

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ring to what some will consider the most interesting feature of the book, and others will pronounce its chief blemish—namely, the historical and controversial part relating to Westminster.

In this part of the book Mr. Denison, who has had the principal superintendence of both the clock and the bells, and has had a good deal of controversy to carry on, and the failure of two cracked bells to defend or explain, has the advantage of an uninterrupted opportunity for putting before the reader, undisputed, that version of the whole series of transactions which suits him best. The general impression left by reading the whole is, that, after all the ability shown, it is a pity Mr. Denison should have touched the subject at all.

It is clear that he brought both extensive knowledge and great industry to bear upon the undertaking, but there are sometimes other qualities wanting to insure success; and when we know that both the bells which Mr. Denison certified have cracked, and when it is stated by him as regards the first, that Mr. Taylor, the joint referee, "did certify his approval very unwillingly;" and admitted that the second was porous on the surface when it was delivered, only that the holes were filled up with a composition which the referee ought to have been able to detect, we cannot quite coincide with the unqualified terms in which *all* the blame is laid upon the bell founders, the clerk of works, Sir Charles Barry, and every other person connected with the work, except the gentleman principally reponsible.

The whole history of the concern is amusing enough, but the most valuable part of it to practical readers is to be found in the hints "on trying bells," which embody some precautions that were, and others that were not, taken at Westminster. As a specimen of this part of the book, selected almost at random, we quote a paragraph relative to Messrs. Warner's first bell:

"Of course the founders declare the cracking was no fault of theirs; that was quite impossible: 'if the bell had only been struck with a clapper of 5 or 6 cwt. it would not have cracked.' Most likely not; and if every bell that was ever cracked in the world had been struck with a clapper of only half the weight that cracked it, it would probably not have been cracked. But with all submission to the bell-founders, I am of opinion that a bell which will not stand such a clapper or hammer as is actually found necessary to make it sound properly, is *ipso facto* proved to be a bad one, although it may be difficult or impossible to ascertain until it is broken up and the metal examined, what the real or the principal defect is. In that bell of Messrs. Warner's there was no difficulty in discovering one quite sufficient defect, viz., the excess of thickness, not merely of ⅛ inch in the sound-bow (which would have done no harm), but an increase from 4½ inches, which was the prescribed thickness above the sound-bow, to 5⅜ inches. That was the cause of the excessive obstinacy of the bell in speaking out except under a clapper of that unusual weight; and Messrs. Warner are perfectly right in saying that that cracked it. The only difference between us is, that I think the fault lay with those who made the bell so different from the prescribed pattern, and contrary to all precedent besides, as to require a force to bring the sound out which the bell itself would not stand; while they want to throw the blame on those who ordered and rang the clapper so to make the bell give out its sound.

In fact, it never is the founder who cracks a bell. Even if he makes the clapper and hangs the bell, he does not ring it; and bells do not crack of themselves. The above-mentioned bell of Sherborne Church, called Cardinal Wolsey's, though it had been recast in 1670, cracked almost immediately after it was rehung and the clapper altered by Mr. Mears in 1858. Of course the ringers did it. His first Montreal bell of 7 tons cracked about as soon as the two Westminster bells; and he and the people who saw the fracture there have very different opinions about the cause. I know a gentleman who saw it broken up. And we know that he and his allies were going to swear that his Westminster bell was cracked by the hammer being too heavy, although it was within the weight specified in his contract, and lighter in proportion than the ringing clappers (which always strike much harder) of the great bell of Paris, and other foreign bells."

The Parliamentary reports we have referred to at the heading of this article will give, to those curious in the matter, the reports of Professor Tyndal, the Astronomer Royal, and Dr. Percy, on the clock and bells. They describe the present condition of the great bell, and agree in asserting that the cracks in it do not perceptibly interfere with its tone, so that it might still be rung with certain precautions; and they even hold out the probability that the cracks might not get worse, and that the bell might after all be made serviceable. The opinions of those distinguished men of science agree pretty nearly as to the causes of the cracks, and two of those assigned by them lie clearly beyond the control of the bell founder, namely—that the composition prescribed is believed to be too brittle, and the hammer too heavy and with too long a stroke. For the other suggested causes of failure, the founder, no doubt, is responsible, namely—the want of homogeneousness in the composition of the metal, and its being more porous than it ought to be, and having small pits on its surface and cavities in its substance. One thing is clear, namely—that a good deal of money has been spent, and if the public are not to have their money's worth in bells, it seems desirable that they shall have as much as they can get in the shape of experience about bell founding; and on this ground we are glad of Mr. Denison's valuable little book, and cannot help hoping that it may be followed by other publications on the subject.

THE NEW DRINKING FOUNTAINS OF LONDON.

We cannot but express much regret that the major portion of the drinking fountains recently erected are, with reference to their design and the material employed, of the most unsatisfactory description. It is to be hoped, however, that in these respects great improvements will ultimately be effected. At the meeting of the "Drinking Fountain Association" lately held in St. Martin's Hall, Mr. John Bell, the sculptor, very justly urged the necessity of observing a higher tone and a more artistic mode of design than have hitherto been manifested in carrying out the objects of the Association.

With most of the remarks of Mr. Bell we cordially agree, but from his advocacy of the use of iron and bronze as proper materials for the construction of drinking fountains we must dissent, believing that these and other metals are totally unfit for works that are perpetually subject to the action of water. We consider bronze utterly unfit for out-door statuary work of any description in our London atmosphere. An examination of the group in the quadrangle of Somerset House, the statue of the Duke of Bedford, Bedford-square, the bassi-relievi and capital of the Nelson pillar, the statues of the military Napier and Dr. Jenner in Trafalgar-square, and numerous others, show most unmistakeably that bronze is one of the very worst materials that can be used for out-door purposes in London, more particularly for works of statuary and ornamental architecture; in two or three years after works of this description have been exposed to our London atmosphere they become black, dismal, indefinable masses, in which the modelling, however beautiful it may have originally been, is entirely lost.

Bronze may be worked and applied with good effect in the clear atmospheres of France, Italy, and Germany, where it retains its colour and sharpness of outline; but it is totally unfit for the English climate. The great plea amongst sculptors for the use of bronze is its durability, which in some cases is a fallacy; we may instance the group in the quadrangle at Somerset House already referred to, as an example. It was fixed in the time of George III. only, and already shows symptoms of decay, presenting to the eye a black, unattractive mass. There are three materials much better adapted both by beauty of colour and durability than bronze, either in general out-door statuary or fountains; these are granite, Sicilian marble, and sandstone —the former to be procured from the quarries in Cornwall, at Aberdeen, and in Leicestershire; the marble from the primitive rocks of Carrara; and the stone from Cragleith, Binney, Darley Dale, the Forest of Dean, and other localities in England. All real works of sculpture should be cut from the solid, all others are surreptitious. In bronze works, the statue or group as the case may be, is merely made from the clay model, not carved from the marble or stone; and if the modeller be not a consummate artist, the bronze must ultimately be a failure. In monumental sculpture nothing above mediocrity has been produced among us during the last fifty years. Chantrey's genius was of a limited kind; he could not go beyond a bust or single statue, but these however he did in perfection.

It is to be regretted that the public drinking fountains of London have in some instances been made the vehicles of ostentatious display for the gratification of personal vanity. On one of most wretched design, just erected in front of St. Dunstan's Church, Fleet-street, the donor's arms are emblazoned at the top within gilded scroll-work, and around this are inscriptions informing the passer-by of the date of certain events in the personal history of the donor, all of which appear to us quite inconsistent in such a place.

Great credit is due to the promoters of the Drinking Fountain

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Association for its establishment and the vigour of its operations; but it is very desirable that the committee should obtain superior talent for the production of designs, and employ a more suitable class of materials. In the construction of a drinking fountain the basement should generally be of granite, and the superstructure either of good stone or Sicilian marble—materials durable, but not liable to corrosion.

Among the drinking fountains recently erected in the metropolis is one in the Green-park, from the designs of Mr. Sydney Smirke, architect. It is of stone, and is a very favourable example both in design and workmanship. It was executed by Messrs. Edwardes, Edwards, & Co. Another has just been finished in the Strand, at the western end of the church of St. Mary-le-Strand. This production has a nondescript square red granite basement, upon which are placed six fluted bronze spindles—they cannot be called columns—set within a circle, and surmounted by a marble cornice of highly questionable detail. This is crowned by a muddy red-coloured roof, having at the summit a miniature gilded cupid without wings.

The principal faults of the drinking fountains hitherto erected in London appear to be, that they are all too small, and that they are so cut up by the employment of many different materials in the same work, as to lose all harmony of design and good effect.

COWPER'S PATENT HOT-BLAST STOVES.

The improvements recently made by Mr. E. A. Cowper in regenerative hot-blast stoves were fully described by the inventor in a paper lately read by him before the Institution of Mechanical Engineers, a report of part of which, with illustrations, appeared in our last number, and the remainder will be found in our present issue, at page 297; to both of which we beg to refer our readers. The importance of the subject has led us to make inquiries relative to Mr. Cowper's improvements, and we feel that the attention of ironmasters should be directed to the important practical results he has obtained. It appears that much greater economy may be exercised in the mode of heating the blast for blast furnaces, and by using much hotter blast in the furnace at the same time.

The construction of the stoves is simple, and promises the advantages of improved quality and increased capability of reducing refractory ores, at the same time producing an increased quantity from the same furnace, and what is more important, from the same quantity of blast, or rather from the same quantity of cold air blown in by the blowing engine; for the air being increased in bulk by the very high temperature to which it is raised, will supply larger tuyeres. This will be seen from the following table of the expansion of air by heat:

Say air at	62	degrees equals	1	volume.
Then air at	572	,, ,,	2	,,
	827	,, ,,	2½	,,
	1086	,, ,,	3	,,
	1337	,, ,,	3½	,,
	1592	,, ,,	4	,,

It is not, therefore, surprising that the "make" of a furnace should be greatly increased by blast of such a high temperature as 1300° Fahr.

It has been found from numerous comparative observations, taken with the new stoves off, and with them on, that the iron is improved about one number by the hotter blast from one tuyere only (there being four other tuyeres blown at the ordinary temperature); so that if No. 3 is produced without the new stoves, No. 2 is produced if they are put on to a single tuyere.

We understand that the patentee does not assert, that inasmuch as one tuyere with the hotter blast increases the make 10 per cent., that therefore if all five tuyeres were supplied with the hotter blast they would infallibly increase the make 50 per cent.; but it appears probable that such a result would follow. This will however soon be tested, as we hear that eight or more large firms in different places have determined upon putting the new stoves to work immediately on an extended scale.

It appears to us that the saving of the cost of all wear and tear of cast-iron stove pipes usually employed (there being none in Mr. Cowper's stoves) is a great point, involving the prevention of loss by stoppages from the pipes being burnt out, or becoming too leaky for use, which under the old system is constantly occurring. Another advantage, the prevention of all leakage of blast in the stoves, is very important, even in cases where it has been decided that the temperature of the blast shall always be kept low (or as some call it, "warm air"), and where gas from the top of the furnace is used as fuel. In cases where the stoves are heated with coal of any kind, or "slack" or "dross," there is also the absolute saving of a large portion of such fuel. The temperature of the chimneys of ordinary stoves is generally about 1280° to 1500°, showing that the heat of the fire has been but very imperfectly absorbed, thus causing a great waste of fuel, whereas in Mr. Cowper's stoves the chimney is below the temperature of boiling water, or about 200°, proving that the heat given off by the fuel has been absorbed and utilised. This effect is mainly attributable to the employment of the important invention of Mr. Siemens, viz., the application of a large sponge or filter for the heat, called by that gentleman a "furnace regenerator," and which, by its arrangement in Mr. Cowper's stoves, arrests and absorbs the heat from the products of combustion before they can make their escape up the chimney.

The great saving, however, takes place in the blast furnace itself, where a smaller quantity of fuel suffices to produce the temperature necessary to properly reduce the ore; and as it is well known that the chief impurities found in the iron are derived from the coal or coke used in the furnace, any reduction in the quantity of fuel must reduce the amount of impurity; so that as long as there is an ample supply of carbon present in the furnace to thoroughly carbonise the iron and to produce the necessary temperature, the quality must be improved by the reduction in the quantity of fuel employed.

It is probable that certain very refractory ores, which it has hitherto not been worth while to work, may now be used, as was the case with the "black band" ironstone, which required the hot-blast to work it.

Many of the most experienced ironmasters and furnace managers will not allow their stoves to be so pushed that the blast shall be hotter than sufficient to "cut" lead (though they make the blast cut zinc, which melts at a considerably higher temperature than lead), as the chances of injury to the stoves are considered so great as to render it inexpedient to go higher; this course gives the stokers a wider margin between the temperature which causes injury to the stoves (a little above the cutting of zinc) and the working temperature. It is impossible for the stokers who work day and night, exposed in all weathers, to keep the fires of their stoves regular in their heat, and therefore a large margin must be allowed them, unless they are at all times exceedingly careful in their stoking; and if gas from a close-topped blast furnace be used to heat the stoves, although it is then possible to keep them more regular in temperature, still the oxidising and injurious effect of such gas on the iron pipes is so great, that many of the best ironmasters will not use it for this purpose, although they use it under their boilers. In such cases, therefore, the new stoves will save all the fuel at present used for heating blast. The new stoves are adapted for either coal or gas as fuel.

The subject of taking the gas from the top of the blast furnace for use in heating hot-blast stoves, boilers, &c., is a very important one, and will probably occupy the consideration of improving ironmasters far more generally than it has hitherto the success which has attended the practice in South Wales and in the Cleveland district being established; whilst in Staffordshire but very feeble attempts have been made, apparently from the unnecessary fear that exists of closing the top of the blast furnace altogether, and conducting the gas away by pipes for use. This is the only way of bringing the gas thoroughly under control, and preventing the working of the furnace, stoves, &c. being interfered with by a high wind or other variations in the atmosphere.

It will not be very long before our neighbours across the Channel will cause the demand for iron to be considerably increased, and it appears to us that Mr. Cowper's hot-blast stoves have been introduced just at the proper time for increasing the make of iron in our present furnaces, without the necessity of building new ones. Considerable interest has already been excited in several countries on the Continent in reference to this invention, and it is likely to be adopted in many places there, where improvements in the manufacture of iron are now for several reasons receiving a large share of attention.

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NOTES OF THE MONTH.

Talaton, near Ottery St. Mary, Devonshire.—The church of St. James in this place, which had become ruinous in 1858, has been, with the exception of a fine old tower, rebuilt from the foundations, at an expense of about £1500, with the addition of a new north aisle, in place of a west gallery, which has been removed. The three windows in this aisle, and the east window of the chancel, are filled with stained-glass, by Messrs. Hughes (late Ward and Nixon), of Frith-street, London. The chancel-screen has been restored; it is an ancient richly-carved specimen, of the true Devonian type, in the Perpendicular period, and extends across the whole width of the building, including also a parclose screen. There has been added a handsome oak pulpit. These latter have been perfected in their enrichments by Mr. Ship, carver, of Bristol. The architect was Mr. Ashworth, of Exeter. The church was re-opened on the 5th of last month.

Netley Abbey.—The restoration of Netley Abbey, on the banks of Southampton Water, is progressing. Lately the workmen engaged in restoring the abbey discovered the grave and tomb-stone of one of the monks. According to the inscription on the stone the name was John Wade, and he died in 1431. An inscription has also been discovered at the base of one of the columns in the chapel, from which it appears that the abbey was built in the reign of Henry III. A small chapel is to be built by the side of the abbey for the performance of divine worship.

Steam for Towing on Canals.—The use of steam-tugs instead of horse-power for towing boats on American canals is working satisfactorily. One tug having four barges in tow, carrying an aggregate cargo of 674 tons, moved steadily on, at the rate of three miles an hour, and it is said a couple more of boats might have been hitched on without diminishing speed, or much increasing the amount of steam used. This tug, called the Dan Brown, with her four barges, made the passage between Buffalo and Troy, New York, in seven days and sixteen hours, which is two days quicker than it is usually made by horses.

Ward's Ocean Signal Telegraph.—Mr. W. H. Ward having brought his experiments with the ocean signal telegraph to a favourable issue at Woolwich, has received instructions from the Admiralty to embark on board the Royal Albert at Milford Haven, for a course of experiments at sea.

Davies's Patent Self-adjusting Ventilator.—We have examined a ventilator recently patented by Mr. John Davies, which has already been successfully applied at the new Reformatory, Grotto-place, Marylebone, under the supervision of Mr. T. Harris, architect, and which has obtained the unqualified commendation of the committee of that establishment. It is simple in construction, and perfectly self-adjusting. It can be made of iron, brass, copper, or other metal. The invention of Mr. Davies is applicable, not only to schools, but also to public and private buildings of every description, and individual bed-rooms and dormitories, in which pure fresh air is so highly desirable. Mr. Hale, 27, Queen Anne-street, Cavendish-square, is the agent in London for the inventor.

Bitumenised Paper Pipes.—The ingenious idea of hardening paper by means of an admixture of bitumen under the influence of hydraulic pressure, so as to convert it into a substitute for iron, is due to M. Jaloureau, of Paris. Testing experiments, conducted under the great clock-tower at the Houses of Parliament, are reported to have "proved that the material, while it possessed all the tenacity of iron, with one-half its specific gravity, had double the strength of stoneware tubes, without, moreover, being liable to breakage, as in the case of other material, and which frequently causes a loss to the contractor of some 20 or 25 per cent. on the supply." To test their strength, two of these bitumenous paper pipes of 5-inch bore and half an inch thick were subjected to hydraulic power, and they are said to have sustained, without breaking or bursting, a pressure of 220 lb. to the square inch, or equivalent to 506 feet head of water. The cost of the pipes is understood to be one-half the cost of iron. Specimens of pipes employed in the transmission of gas at the Hôtel des Invalides during the last eighteen months were exhibited by Messrs. Joske and Young, the proprietors.

Western Railway of France.—On this railway there is, in addition to the engine-driver and fireman, an inspector, who rides upon the engine, and who attends as far as possible to the general observance of signals made from or accidents happening to the train.

Indian Railway Profits.—According to Mr. Danvers' return, it appears that the profits hitherto realised on the sections of Indian Railways opened in the three Presidencies have been—East India 7½ per cent., Great Indian Peninsular 6 per cent., and Madras 3 per cent. When the debt accrued on guaranteed interest is paid off, the East Indian shareholders will divide 6¼ per cent. instead of 5, and the Great Indian Peninsular, 5⅝ per cent.; the surplus over the 5 per cent. being divided between the government and the shareholders. The shareholders will not draw the full profits.

A Subway in London.—The Metropolitan Board of Works report that, with a view to the adoption of means for obviating the expense and inconvenience attending the breaking up of the pavement for the repair of mains and pipes, sewers, and other underground works, and in the hope of obtaining valuable data for their guidance in carrying out future improvements, they determined in making the new Covent-garden approach to form a subway under the street for the reception of gas and water mains, electric telegraph conductors, &c.; and on the 31st of July they entered into a contract for the execution of these works, and they are now in hand. They propose to construct under the street an arched subway 7 ft. 6 in. in height by 12 feet in width, and also to form arched side passages for house service pipes, together with proper cellarage on each side of the street. In conjunction with the works proper sewers will be built, and convenient arrangements made for drainage.

The Armstrong Gun.—The Select Committee of Woolwich Arsenal have for some time been engaged in proving a twelve-pound Armstrong gun, under a course of the severest conceivable tests, with a determination of over-loading and firing until some portion of the gun should give way. The experiments, which have extended over some weeks, and are now terminated, have taken place in the Royal Arsenal butt, the committee having arrived at the conclusion that no amount of charge can have the slightest effect in shaking the metal. The trial commenced with loading and firing seven rounds with an ordinary proof-charge of powder and a single cylinder shot, after which the charge of powder was increased, and the length of the cylinder shot was doubled. Seven rounds were again fired, and the gun, having been searched and examined, was found intact. A course of trials was subsequently followed up with a gradual increase of the charge and a progressive lengthening of the cylinder, which ultimately consisted of eleven elongated shot, the last of which projected beyond the muzzle of the gun. In order to augment the severity of the test, the cylinder was rammed firmly home and cemented to the muzzle with molten lead and resin, and everyone expected that the gun must inevitably give way. Seven rounds were fired with each increased charge, the result of the last seven rounds carrying the cylinder, weighing 132 lb., completely through the huge mound of earth against which it was fired; and the gun, having been carefully examined, exhibited no symptoms of injury.

Competition.—The Council of the Yorkshire Agricultural Society are desirous of receiving designs and plans of cottages and farm buildings, and offer the following prizes:—1. For a double cottage, containing not less than three bed-rooms in each, cost not to exceed £220 the pair, £25. 2. For the best plan of a double cottage, containing two or three bed-rooms, cost not to exceed £180 the pair, £25. 3. For the best plan of a single cottage, cost not to exceed £120, £25. 4. For the best plan of a pair of cottages of irregular design, cost not to exceed £210, £10. For the second best ditto, £5. *Farm buildings.*—1. For the best plan of farm buildings adapted for a farm of not less than 500 acres, £50: the prize in this class will not be given to any plan which does not provide for the use of steam-power. 2. For the best plan of farm buildings adapted for a farm of 200 acres, £25. Plans of cottages in competition for the prizes must be sent in by the 15th November, 1860, and the plans of farm buildings by the 1st December, 1860. Particulars and conditions of competition may be had of the secretary, Mr. John Hannan, Kirk Deighton, Wetherby, Yorkshire.

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MARSHFIELD SCHOOLS, MONMOUTHSHIRE.

(With an Engraving.)

The schools of which we give an illustration and ground plan have lately been erected at Marshfield, a village between Cardiff and Newport, Monmouthshire. They are intended for the accommodation of about 200 children. The school-room was an old barn altered for the purpose, and a class-room and master's residence and outbuildings have been attached thereto. The material is sandstone with Bath stone dressings, with some polychromatic decorations in red and black brickwork. The end windows of the school-room have detached shafts, the glazing being clear of the same in wood frames. The entire cost of the buildings, the fittings, and the laying out of the ground with fences, &c., has been about £1000. The principal feature in the design is the lean-to verandah-like roof projecting before the centre building, which contains the class-room, and affords shelter for the passage from the house to the school buildings. This is supported upon freestone brackets springing from columns with carved capitals, as may be seen in the engraving. The roofs are open-timbered, stained and varnished, as also are the benches and other joiners' work. To Sir George Walker, Bart., and the Rev. Samuel Evans, the incumbent, is due the credit of having carried out the whole in a most substantial and excellent manner in the face of great difficulties, owing to the failure of the contractors, and the limited means of the parish.

The schools were erected from the designs of Messrs. Prichard and Seddon, the diocesan architects for Llandaff, and of No. 6, Whitehall, London.

SUSPENSION GIRDER BRIDGES FOR RAILWAY TRAFFIC.

The construction of four new bridges across the Thames, completed or in process, in the short distance between Hungerford Pier and Chelsea Reach, and designed on the several systems of suspension chains, arch, arch-girder, and girder, has the effect of bringing obviously before the eye of the public the working out of different theories of construction, which would otherwise be rather of a scientific or professional than of a general interest. It may therefore prove not unseasonable, nor perhaps wholly unprofitable, to dwell a little on the subject handled by Mr. P. W. Barlow, F.R.S., in his paper read before the British Association at Oxford, a report of which will be found *ante* page 225.

Is it expedient, in the construction of bridges of large span for railway traffic, to employ chains, relying on a girder platform to reduce within safe limits the wave that inevitably accompanies the transmission of a rolling load over a common suspension bridge?

The question has been put to a practical test in Mr. Roebling's railway bridge over the Niagara; where a span of more than 800 feet is crossed by means of wire chains supporting a roadway and railway platform; the two platforms being so connected by means of trussing as to form a deep girder. In traversing this bridge the trains proceed at a foot-pace, and the accounts which reach this country as to the degree of disturbance caused by their transit are somewhat conflicting. Its engineer is, however, understood to be as fully satisfied with the steadiness of the structure as he has every reason to be with the remarkably low cost. There is an additional safeguard against undulations in this bridge; cables being attached under the platform, and anchored to the rock below, thus serving as powerful stays: an excellent precaution, but one for which there would be no facilities in the majority of cases. A peculiar feature is the employment of a distinct set of chains for each platform; the deflection of one pair of chains being thus considerably greater than that of the other. It would follow that on any considerable change of temperature, the chains supporting the upper platform would naturally rise and fall appreciably more than those supporting the lower one; and as these platforms are firmly trussed together, it does not appear in what way the danger is avoided of an undue proportion of the weight of the entire structure being occasionally thrown on one set of chains. The extension of the chains when a heavy load comes on the bridge would tend to bring about a similar result.

There are, therefore, special circumstances about this bold and original work which prevent its being taken as a pattern or sample of suspension railway bridges; and very precise data must be obtained by means of careful observations before any general practical conclusions can be drawn from the success of the Niagara Bridge.

The question, then, of the suitability of suspension bridges with rigid platforms to the requirements of railway traffic, is as yet to be regarded as a matter of opinion; and there are few points on which the opinions of engineers of the greatest eminence and talent are less agreed than on the one now under consideration. The two master-spirits, who have left lasting monuments of their constructive genius in the railways of Great Britain, have strikingly exemplified the divergence of their views, in the bridges erected by the one over the Menai, the Conway, and the St. Lawrence; and, by the other, over the Wye and the Tamar.

The enormous strength and rigidity of the Menai tubes is such, that the addition of suspension chains would be simply useless, if not even detrimental. For the expansion and contraction due to extreme changes of temperature would cause the chains to rise and fall midway between the piers, to an extent to which the tube would not readily adapt itself; so that the main weight of the whole structure would sometimes be carried by the chains and sometimes by the tube. It was well known that Robert Stephenson was no advocate for the use of chains for railway bridges in any case. But, conclusive as the consideration just stated is against the combination of a chain with a beam of the proportionate strength of the Menai tube, it does not apply to a suspension bridge with a platform flexible enough to rise and sink as expansion or contraction may require; and at the same time, stiff enough to insure the equable distribution of any partial load over the whole length of the chain.

The bridge over the Wye at Chepstow, and the very similar but more colossal structure over the Tamar at Saltash, have much in common with the description of stiffened suspension bridge so strongly recommended by Mr. Barlow; but are distinguished by two main points of difference. In the first place, the tension of the chains is sustained by straining-tubes resting on the summits of the piers, instead of by the ordinary stay-chains; in the second place, the platform girders are very slight, and the wave is prevented mainly by the introduction of iron trussing in the space between the tube and the chain.

Similar diversity of views may be seen exemplified at Chelsea and Hungerford. The massive chains of the new Chelsea Bridge, and the strong *gridiron* arrangement of the suspended girders, defy all the shocks and disturbances of common wheel traffic. At Hungerford a girder bridge is in course of construction, which would exhibit as marked a contrast to the fine suspension bridge of Brunel, as yet undisturbed, as the Britannia tubes present to the chains of Telford, at Menai. This new work seems to evince, on the part of its distinguished author, a persuasion that the use of chains is inadmissable under any circumstances in railway bridges; for, had it been thought practicable and safe to throw a suspended girder across the span of 670 odd feet, the existing piers would have presented singular facilities; the extent of the foundations being sufficient for a greatly increased width of roadway.

On the other hand, Mr. Barlow records a no less decided judgment on the part of Sir W. Cubitt and himself, that a simple suspension bridge, with a tubular girder roadway, may be traversed by railway trains with perfect safety and small disturbance.

It is therefore sufficiently clear, that if we consult the opinions even of the men most competent to pronounce on such a question, we are led to very opposite conclusions; and until the experiment is actually made on a large scale in some railway bridge, our only remaining resource lies in experiments on models, or in theoretic deductions.

The economy of the ordinary suspension bridge is mainly due to the property possessed by chains of adjusting themselves to any curve of equilibrium required by a new disposition of the load.

In the arch, if a load becomes so distributed as to throw the line of pressure near the edges of the voussoirs, the tendency of the thrust is to cripple the arch, and destroy equilibrium. As a rolling load traversed the bridge the line of pressure (in which the thrust is considered to be transmitted from the crown to the abutments) would, if it could be rendered visible, be seen to waver and distort itself. A bulge or swell would travel along it, raising it perceptibly at the successive points over which the

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load passed; and elsewhere it would be depressed and flattened. To insure the stability of an arch under all possible conditions it is therefore necessary to give a far greater depth of voussoir, and consequently to employ a much larger amount of material than would be demanded simply to sustain the thrust. In girder arches there is a similar necessity for an excessive amount of material, either in the bow itself or in spandrels or trussing, to arrest change of form.

The effect of tension, on the other hand, is to guide the suspension chain into its position of stable equilibrium; so that if only sufficient play is afforded for spontaneous adjustment, no more material need be used than is required to sustain the simple strain of tension. A second advantage possessed by suspension over other wrought-iron bridges results from the whole of the metal being employed to resist a tensile strain, no part being in compression. This causes a saving of material, on account of the strength of wrought-iron to resist extension being considerably greater than its strength to resist compression. A third source of economy is one also shared in some degree by arches, and lies in the deep versed sine which can be given to the curve of the chains. The greater the versed sine, or rise, of the chain or arch, the less is the tension or thrust, and consequently the less is the material necessary to sustain it. An analogous reason renders it advantageous to increase the depth of a girder to a certain extent, but within far narrower limits; as the necessity of providing for lateral stiffness as well as the weight of web or trussing absorbs much of the saving that would otherwise be effected in making girders very deep. A fourth advantage in favour of the suspension bridge is, that the reaction which maintains the tension of the chains is furnished by stay-chains attached to their extremities; while in the girder an upper flange must be provided, the compression of which reacts against the extension of the lower flange, giving a double amount of material in flanges alone, as compared with the chain. To all these reasons for the great economy of suspension bridges, add the important consideration that in considerable spans the weight of the bridge itself begins to bear a large proportion to the total load, a proportion which rapidly augments as the length of bridge is increased. It is thus that for spans of 300 or 400 feet the cost of the girder becomes enormously greater than that of the chain, and that suspension bridges can be thrown over spans utterly impracticable for any other kind of structure. Of course, in any viaduct it is of primary importance to avoid large spans as far as practicable. But cases will occur in which it is difficult or impossible to do so. Must the railway engineer in these cases forego the advantages peculiar to the suspension bridge? Further, in positions where the least practicable span exceeds the possibilities of a girder bridge, is he to reject the only description of structure that will meet the requirements of the case? If it is in the power either of experiment or of analysis to throw any fresh light on this vexed question, the study cannot be deemed unimportant or uninteresting.

Great allowances are necessary in drawing any conclusions as to a proposed work of considerable magnitude from experiments on a model, however carefully conducted. And, in fact, it is almost essential for theoretic analysis to go hand in hand with experiment, to assure us that we are justified in accepting such conclusions as valid guidance for a great work, especially if of a novel character. On the other hand, in analysis, if the reasoning is sound, and if we have ground for believing that nothing has been omitted or mis-stated in the data, there is a fair presumption of the correctness of the result: and if this result is found to agree with experiment, few will hesitate to admit its truth.

It is therefore now proposed to inquire, what solution theory affords to the problem of the suspended girder; and while doing this it may be useful to note how far the results arrived at accord with Mr. Barlow's experiments. It will then be endeavoured to indicate some general practical conclusions. It might have been of great help in such an inquiry to have been made acquainted with the course of reasoning pursued by Prof. Rankine, and to know the process by which the learned professor arrived at the conclusion cited in Mr. Barlow's paper. In the absence of the guidance which such knowledge might have afforded, it is necessary to proceed as upon untrodden ground.

If a weight be placed on any part of a girder suspended from a chain, but having its ends kept from rising at the piers, the chain will be observed to be drawn down by the loaded girder, and the further parts of the chain will be drawn up, drawing with them the girder. The girder will thus assume an S bend, with an additional half-bend in cases when the weight is applied near the half-span. What is the law of this compound displacement? The reason that part of the platform is drawn up when part is deflected, is obvious. The chain is fixed at the ends, and is of a certain length: when a partial deflection takes place, the curvature of the portion of chain immediately affected is increased, and this has the effect of *taking the slack out* of the rest of the chain (the total length being unchanged) by flattening its curvature; which at the same time draws it up, and the platform with it.

First of all, then, the law must be ascertained by which the vertical displacement of any portion of the chain affects the horizontal measurement from end to end. This law is as follows:—Let the variable y be the ordinate of the curve of the chain; and let the vertical displacements of the various points be plotted in a curve, of which the variable z expresses the ordinate. z is therefore, in fact, the total vertical displacement of any point in the chain, and is supposed to be inconsiderable compared with the total rise of the chain.

Let x be the abscissa, or horizontal distance. Then $\int \frac{dy}{dx}\,dz$ gives the total alteration of the horizontal measurement between any two given points of the chain, consequent on the supposed vertical displacements.

If now the wave of displacement of the platform can be resolved into two—namely, first a wave of simple deflection, in which the whole girder would sink under its load if unsupported by the chain, and, secondly, a reflex wave, in which the reaction of the chain pulls up the girder—we shall find the following relation to subsist between these waves. Call their respective ordinates z_1 and z_2: then

$$\int \frac{dy}{dx}\,dz_1 + \int \frac{dy}{dx}\,dz_2 = 0;$$

the integrals being taken for the whole distance from tower to tower. Because, apart from the stretching of the chain, which it is unnecessary at this moment to take into account, any other result would involve an alteration of the span, or a break in the continuity of the chain.

For a girder of a given uniform section the wave of simple deflection may be determined by the ordinary rules. As the resistance of the girder to vertical displacements will be far more powerful than that of the chain, the displacements being very small compared with the versed sine of the curve of the chains, no serious amount of error is involved in assuming that the form of this wave depends absolutely on the girder, without reference to the chains.

We can therefore at once give an algebraical expression for z_1, the ordinate of the wave of simple deflection. Thence can be determined the value of $\int \frac{dy}{dx}\,dz_1 = \mathrm{H}$, the horizontal distance by which the span of the chains would be diminished through the wave of simple deflection, were the effect not compensated by the reflex wave.

The reflex wave must be of a form due to the action of an equally diffused upward pressure on the girder, since the curve of the chains (when the displacement is not considerable) may still be considered to be that due to equal loading; and the equal loading of the chain being conveyed through the suspension-rods attached to the platform, the reaction on the platform must be equally distributed also. For similar reasons to those already adduced, the form of this reflex wave is deducible from the laws of girders simply. Its magnitude—and, in consequence, the proportion which the chains bear of the entire load—is determined by the equation

$$\mathrm{H} + \int \frac{dy}{dx}\,dz_2 = 0;$$

which gives the conditions on which alone the reflex wave can compensate the wave of deflection.

Having thus determined the simple wave of deflection and its ordinate z_1, and the reflex wave and its ordinate z_2; the superposition of the one wave on the other gives the actual compound wave of deflection with its ordinates $= z_1 + z_2$. The actual strain on the girder at any point will be found by subtracting from the strain accompanying the simple deflection the upward strain due to the reflex wave. In fact, the process of the analysis

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has regarded as successive two waves which are actually simultaneous; and by thus resolving the compound wave into its component parts a solution is attained capable of simple and ready application.

If, for instance, it be inquired, what effect will be produced by a weight w placed on the suspended girder at a point distant d feet from the half-span (the ratio $\frac{d}{s}$ being expressed by r), it will be found, on pursuing the method of investigation just indicated, that a distributed pressure will be thrown on the chains

$$=\left(\frac{25}{16}-\frac{15}{2}r^2+5r^4\right)\times w;$$

and that the reflex wave due to the reaction of the chains will have its ordinate at the half-span

$$=k\times\frac{5}{6}\,\frac{s^2}{64}\left(\frac{25}{16}-\frac{15}{2}r^2+5r^4\right)\times w,$$

k being a coefficient depending on the rigidity of the girder, and s being the span. Combining the reflex wave with the simple wave of deflection (determined by the usual rules for girders), in which the same coefficient k will occur, the compound wave is obtained. A correction for the effect of the stretching of the chains, which goes to reduce the reflex wave, remains to be made, and the result is a very close approximation to the actual state of the suspended girder under the assumed conditions.

(To be concluded in our next.)

STREET IMPROVEMENTS IN LONDON.

Resuming our notice of buildings recently erected in the metropolis, the first on the list is the large building on the western side of Bishopsgate-street Within, erected as commercial offices. This building occupies the site of six old shops and houses that formerly stood nearly opposite St. Helen's-place. The street façade comprises three general stories from the street level, which traverse the whole width of the front, while an upper one only embraces the central portion of the composition, and is composed in the uppermost stage of a series of five pointed arches, having chamfered jambs and heads. The ground story has five openings formed of pointed arches, one being the entrance, which is at the extreme side, and is somewhat different in design to the others. These arched openings have their jambs and heads deeply and effectively moulded, and within the latter transoms are inserted of peculiarly original design. The jambs are composed of clustered serpentine marble, which when completed will have carved capitals and moulded bases in stone. The first-floor windows range immediately over the lower ones, and are treated in a somewhat similar manner, excepting that their arches partake more of an Early English character, displaying mouldings embellished with the dog-tooth or nail-head ornament. The windows are divided into two lights by central shafts of serpentine, with caps and bases similar to those below. The upper series of windows is of a less pretentious character, but is admirably arranged so as to produce variety of combination, the central ones being in three pairs, with a larger one, single, at each extremity. The centre groups are each inclosed within a bounding arch, and have an excellent effect, with exceedingly simple and good detail, particularly the label mouldings, which are supported by carvings representing heads and bosses of foliage. The chimneys rise on the front wall of the street elevation of the building, and are very characteristic in their design: unsightly terminations will be avoided, their crowning cornices having a steep bevel at top. The shafts are square and chamfered at the angles, their plainness however being judiciously relieved by ornamental dots worked at intervals on the chamfers.

The building when completed will present a bold and satisfactory attempt to introduce Gothic into our street architecture, in contradiction to those now so much in vogue—the Italian and French Renaissance. The style adopted by the architect, Mr. W. Wilkinson, of Oxford, partakes largely of continental features, with an admixture of English elements well harmonized, and the whole is worked out with considerable skill in the moulded work, and good taste in the carvings. The plain surfaces of the walls are cased externally with red brick; the whole of the dressings of the doorways, windows, string-courses, and chimneys are of Bath stone. The voussoirs of the relieving arches are constructed alternately of Bath stone and the green stone of Moniton, Oxfordshire. The roof is covered with the Broseley mottled tiles, expressly selected for the purpose. The shafts employed in the jambs of the windows and door of the first and ground floors are of serpentine marble, from the Penzance quarries: it is a most beautiful material, highly polished, and is said to be as durable as granite; if so, we should be glad to see it more universally adopted instead of artificial materials. The carvings in stone, which display much diversity of design and artistic handling, are very effectively rendered by Mr. Suffolk, of South Lambeth.

A clever adaptation of Venetian architecture is to be seen in an elevation just erected at No. 53, Red Cross-street, Barbican, known as the Three Tuns Tavern. The street elevation although small, is unique, and is entirely of stone. All the details, whether in moulded work or carving, are well worked out. The ground floor is in three openings as regards the house, with an additional one forming the entrance to Three Tuns-square. These openings are crowned by arched heads of the reversed ogee shape and moulded, having in their spandrels heads of Shakspeare, Milton, and Ben Jonson, we presume in commemoration of the former and latter having, in the days of good Queen Bess, been frequenters of City taverns; and that the great author of Paradise Lost was buried in Cripplegate Church, in the immediate vicinity. These three carvings are introduced in a somewhat original manner, being inserted in the solid wall, in deep concave sinkings, and brought out in alto-relievo. Over the centre of the central portion of the ground floor there is a deep moulded sill, on the face of which is a sunken panel bearing the name of the proprietor. The arches of the ground floor range are divided from each other by stone piers, on the faces of which are three-quarter columns, with carved capitals, grouping leaves and flowers, with the hop and vine, also the rose, wheat, &c. The centre portion of the elevation is composed of a series of windows in four lights; those of the first and second floors being precisely similar in general design. They are separated from each other horizontally by a deep sill and panel filled with characteristic foliage. The whole of the first and second floor windows, together with four blank ones at the extreme sides of the elevation, are of uniform design throughout; they have reversed ogee-shaped heads, but contrary to the lower ones, they are enriched, and their plain spandrels embellished with paterse, cut in sunken circles. The windows are divided from each other similarly to those below, and their shafts have all enriched capitals, some representing the natural leaves of the oak, ivy, vine, clematis, and others treated conventionally. At the top is a somewhat plain cornice supported by small blocks. The roof of the house has not been interfered with, and displays the small, oblong, flat red tiles that were used so much in the reigns of Queen Elizabeth and James. The retention of the old roof is to be regretted: a true Venetian covering, with the picturesque and characteristic chimneys, would have been far preferable. It is to be hoped that the production of this small Venetian elevation may lead to the adoption of the style on a more extended scale, to assist in breaking the monotony of many of our streets. Mr. Arthur Ashpitel, Poets'-corner, Westminster, was the architect of the building; Mr. James Tolmie, of Lambeth, executed the whole of the carvings in stone. The capitals on the elevation are all of different design, and these, with the heads of our three great poets, have been very cleverly treated.

On the southern side of Old Broad-street, the houses Nos. 13 to 17 have been removed, and a fine substantial structure, on a large scale, is in progress; its site occupying the whole area of the old property. The new building is being erected for a banking establishment, from the designs of Mr. Edward M. Clifton, architect. The elevation is Italian, and will be executed entirely of Portland stone.

BRIDGES AND VIADUCTS ON THE RAILWAYS OF SWITZERLAND.

The rapid extension of railways in Switzerland has of late necessitated the construction of a variety of bridges and viaducts in that country, in many of which considerable engineering talent has been displayed by the projector, Mr. Carl von Etzel, Engineer-in-chief of the Central Railway, Switzerland, under whose direction all these works were executed.

A country presenting the physical characteristics of Switzerland naturally throws many obstacles in the way of railway communication, and demands for its accomplishment considera-

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	Lattice Girder Bridges			Wrought-iron arched girder Bridge	Lattice Girder Bridges		
	Over the Sitter, at St. Gallen.	Over the Thur, at Wyl.	Over the Glatt, at Flawyl.	Over the Aare, at Olten.	Over the Birs, at Basle.	Over the Frenke, at Liestal.	Over the Wiggur, at Aarburg.
Number of main girders	2	2	2	5	4	4	4 (D.)
do of lines of railway	1	1	1	2	2	2	2
do of spans	4	4	3	3	3	3	2
do of piers — Material—Stone	—	—	—	2	2	2	1
do of piers — Material—Cast-iron	3	3	2	—	—	—	—
Clear span between abutments ... in feet	524·86	546·5	330	339·5	251·9	177·9	165·3
Length of iron superstructure ... in feet	535·4	456·7	342·5	339·6	259·8	184·3	174·
Height of rails above mean water level ... in feet	204·8	62·7	99·5	(C.)	35·4	49·2	23·6
Weight of superstructure for one line of rails — Cast-iron	10·93	12·37	9·63	... ...	25·68	14·07	13·53
Weight of superstructure for one line of rails — Wrought-iron	330·22	196·86	197·81	... ...	96·92	60·56	73·60
Total weight of superstructure for one line of rails	341·15	209·23	207·44	... ...	122·60	74·63	87·13
Weight of piers, in tons — Cast-iron	902·92	205·60	239·04	... ...	... ...	... ...	... ...
Weight of piers, in tons — Wrought-iron	31·47	13·60	13·09	... ...	... ...	... ...	... ..
Total weight of iron piers ... in tons	934·39	219·20	252·13	... ...	... ...	... ...	... ...
Cost of foundations £	1374 15 6	1155 18 6	591 0 0	2795 16 6	3098 6 6	72 10 6	805 4 0
Cost of masonry £	5992 8 9	3421 9 6	2087 1 6	9244 3 6	2957 4 0	1502 14 6	1592 16 0
Cost of iron superstructure, iron parts £	10451 8 0	7218 12 9	5809 1 6	11960 0 0	3371 9 0	2145 18 6	2595 12 0
Cost of ,, ,, scaffolding or centering £	1984 0 0	359 4 0	632 0 0	... ...	... ...	... ...	... ...
Cost of iron piers, iron parts £	16351 0 0	4095 8 0	4477 13 6	... ...	... ...	... ...	... ...
Cost of ,, scaffolding £	232 0 0	108 0 0	116 0 0	... ...	... ...	... ...	... ...
Total cost of structure £	36385 12 3	16358 12 9	13712 16 6	24000 0 0	9426 19 6	3721 3 6	4993 12 0
Cost of superstructure per foot run for one line of rails	23 8 3	16 11 10	18 17 3	17 12 1½	12 19 7	11 12 10½	14 18 4
Time of construction and erection, in months	30	15	28	23	16	10	15

ble skill on the part of the constructing engineer, both as regards a judicious selection of route, as well as the kind of structure to be adopted, and the carrying out of its details.

In the accompanying table we give a summary of the principal bridge works of interest recently executed in Switzerland, it has been arranged by the designer himself, and reliance can therefore be placed on the exactness of the data it contains. The structures referred to are:

I. *On the Central Railway of Switzerland.*

a. The line from Basel to Olten.

1. The bridge over the Birs at Basel.
2. ,, ,, Frenke at Liestal.
3. The viaduct at Rümlingen.
4. The bridge over the Aare at Olten.

b. The line from Olten to Bern.

5. The bridge over the Wigger at Aarburg.
6. ,, ,, Pfaffnern at Niederwyl.
7. ,, ,, Murg at Murgenthal.
8. ,, ,, Great Emme at Burgdorf.
9. ,, ,, Worblaufenthal at Bern.
10. ,, ,, Aare at Bern.

c. The line from Herzogenbusch to Biel.

11. The bridge over the Great Emme at Dorendingen.
12. ,, ,, Aare at Solothurn.

d. The line from Olten to Luzerne.

13. The bridge over the Small Emme at Emmenbaun.

II. *On the St. Gallen Railway.*

1. The viaduct at Goldbach.
2. The bridge over the Sitter at St. Gallen.
3. ,, ,, Thur at Wyl.
4. ,, ,, Glatt at Flawyl.

All these are (with the exception of two stone structures, viz. the viaducts at Rümlingen and Goldbach, and one wrought-iron arched girder bridge over the Aare at Olten) of the lattice girder class, the three last-named of which are distinguished by being supported by cast-iron piers. The greater number of these bridges is constructed to carry a double line of rails, but the lattice girder bridges enumerated under Nos. 11, 12, and 13, on the Central Railway, and under Nos. 2, 3, and 4, on the St. Gallen Railway, carry only one line of rails. The beautiful bridge crossing the river Aare at Bern, supports, in addition to the double line of rails, a roadway for ordinary traffic, which is situated between the sides of the lattice girders, whilst the railroad is carried above, the transverse sleepers resting on the top flange of the lattice-girders. The two stone viaducts are both inclined, and run in a curve; the wrought-iron arched girder bridge over the Aare at Olten, lies in an incline of 18 in 1000. The Wigger bridge at Aarburg is a skew bridge: all the rest are straight bridges. The above table, for which we are indebted to our able contemporary 'Der Civilingenieur,' contains the principal data respecting them.

In glancing at the last line but one of the table, we observe that in those lattice girder bridges the expenses per foot run of the superstructure increase with the span. This is still more evident by a direct comparison. We obtain the following scale:

Clear span in feet—	55	78·75	94·5	110·25	118	126
Cost per foot run and per line of rail—	£11 12 10	£12 19 7	£14 15 3	£16 11 10	£18 17 3	£23 8 3

The costs of the plate bridges were, at 29·5 feet clear span, £8. 14*s.* 2*d.*; and those of the arched girder bridge, at 103 feet span, £17. 12*s.* 1½*d.* The last-named system is therefore more expensive than the system of lattice girder bridges; whilst wrought-iron plate girder bridges appear, within the limits in which they are applicable, to be cheaper. The fact that the expenses of the superstructure increase rapidly with the span of the bridge—as has been illustrated in the foregoing table—may in those instances afford a point of reference where the extent is limited by the expenditure of capital.

The question however, whether lattice girder bridges with large spans are applicable, is now placed beyond doubt, and has been fully proved by the construction of the magnificent viaduct, on the lattice girder principle, over the river Boyne, on the Dublin and Belfast Junction Railway, the centre span of which measures in the clear between bearings 264 feet. This bridge was proved with a load of 2 tons per foot lineal throughout its whole length, and withstood the test most successfully.

In comparing the span with the cost per foot lineal of superstructure we must, however, not lose sight of one important point, viz., whether the girders of the bridge for each span are detached and unconnected, or whether the girders are of a continuous character, that is, connected together *over* the piers. The latter is the case with the trellis girders of the Boyne Viaduct, and this circumstance contributes, no doubt, not a little to the cheapness and lightness of this elegant structure, as compared with those of a smaller span enumerated in the table.

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Lattice Girder Bridges.								Stone Bridges.	
Over the Pfaffnern, at Niederwyl.	Over the Murg, at Murgenthal	Over the Great Emme, at Burgdorf.	Over the Worblaufenthal at Bern.	Over the Aare, at Bern.	Over the Great Emme, at Derendingen	Over the Aare, at Solothurn.	Over the Small Emme, at Emmenbanm	The Viaduct at Rümlingen.	The Viaduct at Goldbach.
				(E.)				(A.)	(B.)
4	4	4	4	2	2	2	2	—	—
2	2	2	2	2	1	1	1	2	2
1	1	3	3	3	3	3	4	8	5
—	—	2	2	2	2	2	3	7	4
—	—	—	—	—	—	—	—	—	—
78·75	78·75	267·7	267·7	539·3	267·7	307·	370·	418·1	252·9
87·4	87·4	276·4	276·4	551·8	276·4	315·8	378·7	—	—
29·5	37·4	—	—	142·7	—	—	—	80·7	86·6
7·23	7·23	20·57	20·57	63·96	20·57	24·60	27·55	—	—
38·178	38·178	116·01	116·30	878·40	116·01	138·25	158·71	—	—
45·408	45·408	136·58	136·87	942·36	136·57	162·85	186·26	—	—
... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...
... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...
... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ..	... ...
— —	— —	— —	— —	— —	— —	— —	— —	— —	— —
324 0 0	125 16 9	2933 0 0	36 0 0	896 0 0	3154 1 6	6260 16 0	3252 0 0	11628 13 0	9956 9 0
929 4 0	1447 11 0	1467 8 0	4366 0 0	8480 0 0	1295 12 0	3033 12 0	1725 0 0	504 14 0	280 0 0
1350 8 0	1350 8 0	4080 0 0	4086 0 0	28984 0 0	4080 0 0	4860 0 0	5568 0 0		
... ...	... ...	... ...	... ...	3840 (F.)	... ...	... ..	... ...	1600 0 0	1226 16 0
... ...	... . .	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...
... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...
2603 12 0	2923 15 9	8480 8 0	8488 0 0	44144 0 0	8529 13 6	14154 8 0	10540 0 0	13733 7 0	11463 5 0
15 9 0	15 9 0	14 15 3	14 15 8	(G) 58 6 6	14 15 3	15 4 7½	14 14 0	—	—
12	16	24	23	—	18	12	—	16	21

References to Table.

(A.) This viaduct is in an incline of 20·833 in 1000, and runs in a curve of 2600 feet radius. With respect to its cost, £504. 14*s.* is quoted separately as the expense of the balustrade.

(B.) The incline of this viaduct is 20 in 1000, and the radius of curve 1200 feet. The piers are founded on rock. Amongst the items in the table, £280 is specified for the balustrade.

(C.) As the bridge lies in an incline of 18 in 1000, we can only give the height of the rails above mean water level at one particular point, say at the extreme arch, where it is 51·45 feet.

(D.) This bride intersects the river Wigger at a very acute angle.

(E.) The transverse sleepers carrying the railway rest on the top flanges of the lattice girders. The latter support in addition to this, between them, a platform forming a roadway for ordinary traffic. The bridge is extended at each end by a wrought-iron plate girder bridge of 29·5 feet clear span. Each of these bridges consists of four girders, of 43·5 feet total length, and the combined weight of their superstructure is

	Tons	cwt.	qr.
Wrought-iron	41	14	0
Cast-iron	6	12	1
Total . . .	48	8	1

or 11·18 cwt. per foot length. The expenses of the Aare bridge at Bern embrace, in addition to the specified items, £428 for the woodwork of the platform of the common roadway, and £1516 for the two wrought-iron plate girder bridges, which cost accordingly £8. 14*s.* 2*d.* per foot run and for one line of rails.

(F.) This includes an expenditure of £640 for scaffolding used in the erection of the masonry.

(G.) The expenses include here both lines of rails; the cost per foot run and per line is therefore only £29. 3*s.* 3*d.*

THE PERFORMANCE OF STEAM VESSELS.

The following are extracts from a paper by Vice-Admiral Moorsom, on the Performance of Steam Vessels and the Functions of the Screw, read by him before the British Association at the Oxford meeting. The subject is very important, and some of the results deduced by the author are interesting. He says,

"In this, the fourth paper presented by me to the British Association, it may perhaps be desirable to recapitulate the points I have brought into issue, and for the determination of which data only to be obtained by experiments are still wanting, viz.—

1. There is no agreed method by which the resistance of a ship may be calculated under given conditions of wind and sea.

2. The known methods are empirical, approximate only, and imply smooth water and no wind.

3. The relations in which power and speed stand to form and to size are comparatively unknown.

4. The relations in which the direct and resultant thrust stand to each other in any given screw, and how affected by the resistance of the ship, are undetermined.

In order to resolve these questions specific experiments are needed, and none have yet been attempted in such manner as to lead to any satisfactory result.

The Steam Ship Performance Committee of the British Association have pressed upon successive First Lords of the Admiralty the great value to the public service which must ensue if the following measures were taken, viz.:—

1. To determine by specific experiment the resistance under given conditions of certain vessels as types; and at the same time to measure the thrust of the screw.

2. To record the trials of the Queen's ships, so that the performance in smooth water may be compared with the performance at sea, both being recorded in a tabular form, comprising particulars to indicate the characteristics of the vessel, of the engine, of the screw, and of the boiler.

Hitherto nothing has come of these representations. In the paper read last year at Aberdeen, I showed, in the case of Lord Dufferin's yacht Erminia, how the absence of admitted laws of resistance interfered with the adjustment of her screw; and how therefore, as a matter of precaution, a screw was provided capable of a thrust beyond what the vessel required. I also showed, in the case of the Duke of Sutherland's yacht Undine, how her screw, from being too near the surface of the water, lost a large portion of the thrust due to its size and proportions. In other words, a screw capable of giving out a resultant thrust in sea-water of 5022 lb., at a speed of vessel of 9·26 knots an hour, did actually give out only 3805 lb. That is to say, the effect produced was the same as if that screw had worked in a fluid whose weight was about 48 lb. per cubic foot instead of 64 lb."

After exhibiting in detail some other examples from among Her Majesty's ships of war, the author proceeds:—

"I do not know what the naval authorities consider these experiments to have proved. I cannot see that they have been

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conducted on any principle, unless it be the reduction of the area of the blades.

When a screw whose periphery is so near the surface of the water that its rotation breaks up the surface, the resistance to the thrust is not so great as it would be if the screw was lower, and a greater volume of water is pushed back to obtain a fulcrum. This is one cause of what is called the "slip." Another cause is the resistance to rotation, and this has been called "lateral slip." When the corners of a screw so situated are cut off, the resistance to rotation is reduced by so much, and also the narrower edge of the blade disturbs the water less. On both these accounts the slip may be less than before—the speed of the ship a trifle greater. This is generally the case with Griffiths' screw. But the pointed end of the blade is unnecessary if the screw be sufficiently immersed, and no such expedient can countervail the disadvantages of a screw whose diameter brings it too near the surface.

Let the issue be tried by giving the Diadem or the Doris a common screw of 16 feet diameter and 32 feet pitch. One of two things must happen—either the ship will retain the same speed with less power, or the power increasing the speed will increase also—that is, under equal conditions as to trim, tide, wind, and sea.

If an experiment such as this should prove successful, I should then have to recommend a similar modification of screw of a considerable number of the Queen's ships whose performances are before me. I believe it is quite practicable to adjust to a vessel of smaller draught of water a screw of sufficient thrust, whose effect upon the ship in straining her shall not be greater than on a line-of-battle ship of the greater draught.

There is now building at Blackwall the Warrior, a ship to be cased with 4½ inch plates of iron, whose length at water-line is 380 feet, breadth 58 feet, intended draught of water (mean) 25½ feet, area of section 1190 square feet, and displacement about 8992 tons, and she is to have engines of 1250 nominal horse-power. This ship must cost not less than £400,000, and may cost a good deal more when ready for sea. But there is another of similar and two others building of smaller size. What security is there for their success?

The conditions which such a ship as the Warrior must fulfil in order to justify her cost are deserving of some examination. The formidable nature of her armament, as well as her supposed impregnability to shot, will naturally lead other vessels to avoid an encounter. She must therefore be of greater speed than other ships of war. To secure this it is essential that her draught of water should be the smallest that is compatible both with stability and steadiness of motion, and that she should not be deeper than the designer intended. To insure steadiness it is necessary among other things that in rolling, the solids, emerged and immersed, should find their axis in the longitudinal axis of the ship. To admit of accurate aim with the guns, her movements in rolling should be slow, and not deep.

Throughout this and the former papers I have abstained from any explanation of the methods by which I have arrived at the results indicated, such as the direct and resultant thrust of the screw, and the specific resistance due to the form of the ship. The introduction of formularies, by raising collateral issues, would lead us away from the great object I have in view, viz. to show the paramount necessity of experiment to establish data for scientific improvement.

I have referred only to the well-known and admitted formula of Euler, published about 1773, of the weight of water as a measure of resistance. The manner of applying this formula would admit of a discussion that no argument could determine. It can be settled by experiment alone. The conventional formula $K = \frac{S\ V^3}{P}$ is introduced solely for illustration. In all courtesy, and with every respect for anyone who may wish to inquire further, I must decline at present any explanation. The real issues raised are stated at the commencement of this paper.

Any argument on collateral points would be out of place, and not for the advancement of science, which takes no cognizance of reasoning however plausible that does not rest on established facts. Such facts have yet to be established, and that they may be so is one object of this paper."

FREE LIBRARY AND MUSEUM, LIVERPOOL.

This very elegant and commodious building, which was commenced in 1858, has just been completed and inaugurated. The edifice stands upon the north side of Shaw's-brow, the site having a front to that road of about 266 feet, and running backwards to Clayton-street, on the average 198 feet. It extends in front about 222 feet, and in extreme depth about 164 feet, and occupies an area, entirely covered, of about 3770 square yards. The front and the returns, to the extent of about 45 feet at each end, are executed in stone; the remainder of the sides or ends, and the back part or north front, being faced with straw-coloured bricks, with stone dressings. The south façade is broken up into five parts, having in the centre a hexastyle portico of the Corinthian order, with four columns in the rear, and the centre part deeply recessed. The recessed parts of the front contain each five windows, over which are sunk panels, with large carved wreaths on raised blocks. The two wings have on the face four pilasters of like order with the portico, the two centre ones projecting before the line of the angle ones about 2 feet; and between the centre pilasters are niches, with pediment caps and carved trusses, and above are sunk panels and carved wreaths. The flanks to the extent of the stone-work contain the windows which, at the east end, light the students' reading-room, and at the west end the corresponding room in the museum. The columns are 33 feet high; the basement is 9 feet high; and the entire height, from the surface of the ground to the top of the entablature, is about 51 feet, exclusive of an attic or parapet round the building, 7 ft. 6 ins. high, for the purpose of screening the roofs, which would be otherwise overlooked from the higher level of London-road. There is also a lofty raised attic above the portico, returned on each side, for the like purpose of screening the roof of the central hall, otherwise overlooked from the higher ground. The portico is approached at each end by steps, inclosed in screen walls with iron gates, and the remainder of the front is inclosed from the street by a stone balustrade, having iron gates to the side entrances.

The general entrance to the building is from the portico, into an entrance-hall 31 feet by 23 feet, having a flat panelled ceiling. On the right is the reading-room and library, and on the left the museum-rooms. Each of the entrances and the central hall are approached by four steps, the general level of the principal floor of the building being 2 feet above the level of the entrance-hall, and 2 feet 6 inches above the level of the portico floor. Facing the entrance, and beyond the entrance-hall, from which it is separated by a screen consisting of two Doric columns flanked by two pilasters, is the central hall, 90 feet long, 53 feet wide, and 16 feet high. It is surrounded by a gallery, supported upon an arcade, the gallery being 10 feet wide. Above this gallery the roof is supported by twenty Ionic columns, the shaft of each column being one block of stone. Between the columns the gallery is protected by a stone balustrade, and from these columns, surmounted by their proper entablature, spring the groined arches which support the ceiling, the centre portion of which is divided into compartments by enriched bands opposite each column; three of those compartments having horizontal lights, and the others being filled in with enriched panelling and flowers. In addition to the horizontal lights before-mentioned, the hall is lighted on each side by seven circular-headed windows, and by windows in the external walls at the ends of the hall, which are seen partially through the semicircular arches over the entablature surmounting the end columns.

Looking through the far end of the arcade and a screen of two Doric columns, with their flanking pilasters, is the principal staircase, which is 31½ feet by 30 feet. This staircase consists of a central flight of steps and a continuous landing, extending the full width of the staircase, and two return flights of steps. The staircase is protected by Yorkshire stone dado, having moulded plinths, cappings, and pedestals; and the walls round the landings and the sides of the upper flights of steps are cased with Yorkshire stone, with moulded plinth and capping. The upper part of the staircase is surrounded with pilasters and pedestals, to correspond with those in the central hall, and the ceiling is divided by enriched bands into nine compartments, two of which admit the light from skylights, and the remainder are panelled. The room at the south end of the upper part of the hall on the level of the gallery is finished in like manner with the upper part of the staircase; and the upper part of this room and the staircase being each only separated from the central hall by two

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columns, the vista is complete from the front to the back wall of the building, about 152 feet. The central hall is intended for the reception of works of art on the ground floor. The walls of the gallery, the upper part of staircase, and the upper room at the south end, being intended for the reception of pictures.

Descending to the doorway of the entrance-hall, the entrance of the reading-room is on the right hand, through a small vestibule. This room is 110 feet long and 50 feet wide. The south end, forming part of the main building, is separated from the remainder by a screen of two Doric columns, with their antæ. This portion is lighted by the five windows in the eastern recess of the south front. The remainder of the room is lighted by two skylights, and by windows in an attic, raised upon segment and panelled arches across and on each side of this portion of the room. These arches spring from four piers, intended to inclose shafts to be used in the warming and ventilation of the building. To these shafts, and to corresponding shafts in the angles of the room, are attached Doric pilasters, the whole surmounted by a Doric entablature. Adjoining the large reading-room, and in the south-east angle of the building, is the students' reading-room, 40 ft. 6 in. by 28 feet; and on the east side of the reading-room is the reference library, 75 feet by 27 feet, which is fitted up with book-cases, and having a gallery round it for book-cases. North of the reading-room, and divided from it by a staircase and passage, is the committee-room, and also three class-rooms, the staircase being intended for access to the upper rooms of the library, and to the lecture-room.

Upon the upper story of the building, on the library side, are three rooms intended to be used for library purposes. One 50 feet by 27 feet; one 40 ft. 6 in. by 28 feet; and one 75 by 27 feet. These are all lighted from the roofs, and will afford with the lower rooms space for 100,000 volumes. They communicate at one end with the staircase just mentioned, and at the other with the upper room at the south end of the central hall. Over the committee-room is a lecture-room 28 feet by 25 feet; and over the class-room a theatre for lectures, seated with circular seats, capable of accommodating 340 persons. This theatre is approached from the north-east angle of the gallery in the great hall, and from the staircase in the north-east wing. The basement of this eastern portion of the building is in part to be used in connection with the working the library. Again descending to the entrance-hall, on the left hand from the outer doorway, looking northwards, is the entrance to the museum-rooms, on the principal story of which there are five, two of them each 50 feet by 27 feet; two of them each 40 ft. 6 in. by 28 feet, and one 70 feet by 27 feet: having above them the upper museum-rooms, also five in number, and of like dimensions with the lower ones, all lighted from the roof. The basement under three of the rooms has been prepared for the reception of marbles, and such things as would require to be on a solid floor. From the basement, on the west side of the principal staircase, is a staircase for the servants, and to convey the specimens and cases up and down.

The munificent donor of this very handsome and useful edifice is Mr. William Brown, of Liverpool. The building reflects very great credit on the architect, Mr. John Weightman, the borough surveyor, who designed and superintended the whole. The cost is about £40,000. The general contractors were Messrs. Holme and Nichol.

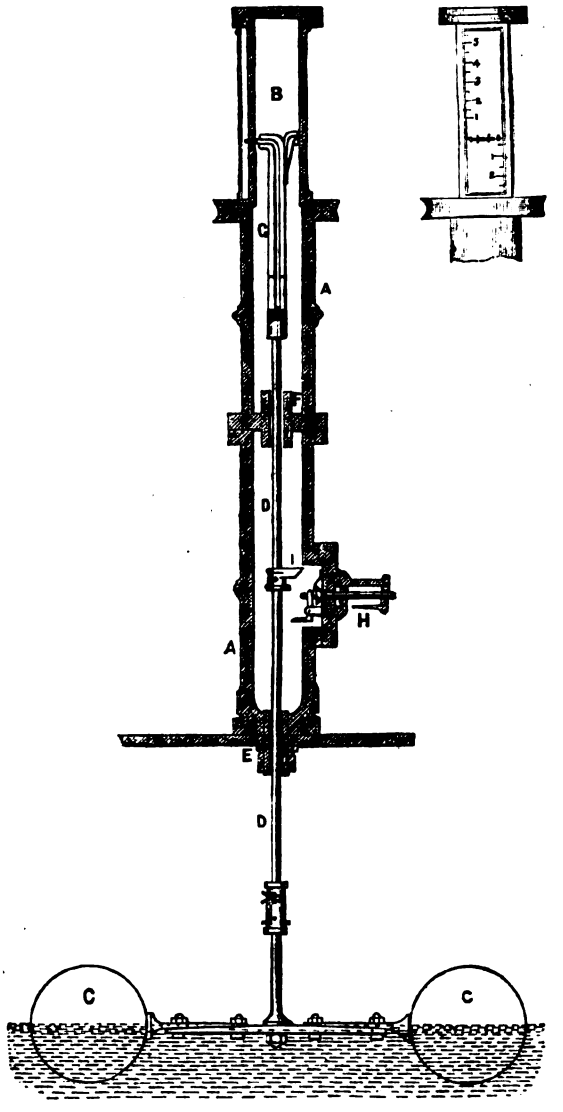
PINEL'S MAGNETIC WATER GAUGE FOR STEAM BOILERS*.

By George Piggott, Birmingham.

Most appliances for indicating the height of water in steam boilers are liable to be inefficient for the purpose, chiefly from undue friction caused by the buoy rod passing through a stuffing-box or packed joint; the packing is often so tight that the float will not move the rod; and if it is packed lightly to dispense with the friction, then there is a leakage of steam, which is very objectionable. The Magnetic Water Gauge described in the present paper, the invention of M. Pinel, of Rouen, is free from these objections: the chief points to be noticed are, its compactness and simplicity, and the facility of fixing, its exactness in working, and durability, and the very little attention required to keep it in working order.

* From a paper read at the Institution of Mechanical Engineers.

The gauge consists of an upright cast-iron pipe A, on the top of which is fixed a brass box B, square in section. A hollow cylindrical float C, proved to stand a pressure of 10 atmospheres, is attached to an iron rod D, passing through the bush E, without any packing, and also through the guide F, perfectly easy and free. To the upper end of this rod is fixed a strong horse-shoe



magnet G, the poles being bent forwards at right angles to the body of the magnet, which falls or rises in the brass box B, with the fall or rise of water in the boiler. On the exterior face of the box is an isolated iron needle, held merely by the attraction of the poles of the magnet, which it follows in all its movements, rolling on the face of the box as the magnet rises or falls according to the height of water in the boiler. The face of the box is silvered and graduated, so that the least movement of the needle is perceptible: it is covered with glass to protect it from dust and injury. On the side of the upright pipe A, a shrill whistle H is fixed, closed by a valve kept shut by the internal pressure of steam: when the float is nearly at the lowest limit of its range, a small stud I, on the rod D, presses on a lever, which immediately opens the valve and allows the steam to sound the whistle: this at once makes known the want of water.

The fixing of the gauge is exceedingly simple, and does not allow any leakage of steam, which is not only a waste, but often injures the plates of a boiler. A hole about 1¼ inch diameter is drilled in the top of the boiler in the required place, and the gauge is fixed upright, the joint being made with india-rubber and a nut screwed on inside the boiler. The length of the buoy rod is adjusted to suit the height of the water it is usual to work at, the float being weighted to sink just half way into the water,

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so that the adjustment is reduced to a mere matter of measurement. The needle points to zero when the water is at its proper working height, and the water level may then be lowered 2½ inches before the whistle sounds; but if it exceeds this limit by ½-inch the whistle will sound the alarm, and will continue to whistle till the water level is raised again. The gauge is sometimes constructed with two whistles, for high and low water. The buoy rod is limited in its motion both upwards and downwards: when the water is raised 6 inches above the proper working height the coupling of the buoy rod comes in contact with the bush E, which prevents the magnet from being forced against the top of the guage; and when the water falls more than 3 inches below its proper level, the brass coupling which joins the magnet to the buoy rod rests on the top of the guide F, holding the buoy suspended till the water is raised high enough to float it again; this prevents the magnet from moving out of the brass box. Neither of these cases ought to occur, but the provision is made in case of their occurrence. The brass box is planed on the back and front, and for a portion of the width on each side, forming a guide for the magnet to slide in. On the back of the magnet is fixed a brass bar, bearing only on the planed surface on each side of the box, by which the magnet is made to slide perpendicularly; immediately under this bar a light spring is fixed to the back of the magnet, also bearing only on the back of the box, which keeps the poles of the magnet slightly pressing against the face.

This water gauge indicates the height of water so exactly, and the absence of friction renders it so sensitive, that the writer has noticed when it has been put just over the fire-place of a double-flue boiler with brisk fires going, that the needle rises and falls with the fluctuations of the water caused by the quick ebullition. The gauge requires scarcely any attention, and the inconvenience of constantly greasing, and watching that the float acts, is entirely done away with. The silvered face is kept clean by washing with soap and water two or three times a year; this is all the attention it requires.

The total number of these gauges now at work is 3500, 65 of which are in England, and the remainder principally in France; all of which are working with as much accuracy as when first put up, and some of them have now been nine years at work. The rubbing of the magnet against the brass box gives it a polish that renders the wear inappreciable; its magnetic power must necessarily be weakened in time from the effects of rust, and it would then require renewal, but at present its durability has not been impaired in any way. As there is no passage of steam through the gauge, the interior is not liable to any incrustation of deposit. Magnetic gauges were put up at the Paris mint in 1855, and have never been touched since that time: they have also been adopted extensively in the French government workshops and in manufactories.

It was stated in the *discussion* that followed the reading of the paper, that Mr. W. F. Batho had had three of the gauges at work at a pressure of 30 lb. to 40 lb., the longest for eight months: no injury had occurred to them, and they continued in good working order. The only danger that could arise would be from the magnet becoming corroded by long exposure to the steam, and in one of the gauges that had been taken down recently and taken to pieces to be examined, there was a slight indication of corrosion commencing on the top of the magnet, where there would always be a little moisture lying from condensation of steam within the gauge.

Mr. W. F. Batho, in answer to a question whether there was found to be any deposit within the gauge to show that water had been carried up into it, replied that there was nothing but a little moisture from the condensed steam; and the whistle on the gauge showed that it was always full of steam, because the steam sounded it as soon as opened. The gauge cost £7. 10*s.* or £7. 15*s.*

Mr. J. B. Neilson thought the magnetic water gauge would be very useful, especially for boilers with internal flues, where it was so particularly important to know the water level correctly. He thought the hollow float exhibited appeared rather light for working the gauge, and that a stone float would be preferable as safer, and more durable, if it could be arranged to be counterpoised.

Mr. J. Robinson observed that there was no stuffing-box for the float rod in this gauge, and therefore no friction to be overcome by the float; so that a light float was quite sufficient to work the rod.

Mr. W. Richardson had used a different construction of magnetic water gauge, on a boiler working up to 50 lb. pressure, situated in a forge, where he was afraid of a glass gauge being exposed to injury, and wanted a gauge that would not be too high up to be easily seen. It consisted of a copper float about 7 inches diameter fixed on a lever, the horizontal spindle of which passed freely through the front of the boiler into the casing of the gauge without any stuffing-box or packing, and carried at its outer extremity a bar magnet fixed at right angles to the spindle and parallel to the float lever, working within the casing of the gauge; outside the casing was a steel indicating finger, working loosely on a pin in the same centre line as the spindle of the magnet, which showed the height of water on a dial plate. The magnet and indicating finger both rotated on the centre point of their length, so that both were completely balanced, and the finger was propelled by each end of the magnet. This gauge had now been at work for eighteen months, and continued perfectly correct; when first put up, immediately over the fire, its sensitiveness was so great from the violent ebullition that the index was very unsteady, and in order to keep the surface of the water quiet a piece of sheet iron had to be fixed horizontally inside the boiler, sufficiently below the surface of the water not to interfere with the range of the float.

Mr. C. W. Siemens had seen a magnetic water gauge brought over from America about fifteen years ago, similar to the gauge just referred to, having a radial needle worked by a magnet attached to the float, but had not seen it put into operation.

Mr. G. F. Muntz observed that there was one advantage in the magnetic gauge described in the paper, that if the magnet ever got out of order and lost its power, the needle would drop down to the bottom of the face, and it would become evident that the gauge was not in working order; but in most gauges having a finger, the finger did not drop when the gauge got out of order, but remained pointing to the dial, and apparently indicating the water level.

Mr. E. A. Cowper thought the principle of the magnetic gauge was a good one, as it did away with the friction of the stuffing-box required in ordinary gauges, which was always liable to be packed too tight, and thereby check the action of the gauge. One advantage in the construction of the gauge now shown was that the needle was made with a small ring round it at each end, so as to roll on the face instead of sliding, which made its motion very easy.

Mr. F. J. Bramwell remembered a magnetic gauge being proposed by Du Trembley several years ago, having a magnet working inside a tube with a ring attracted by it on the outside; but there would be more friction with a ring than with the rolling needle of the gauge now shown.

Mr. C. May said, that if a glass tube were fixed on the top of the gauge, and could be kept clean, the top of the float-rod itself might be seen working within it; and there would be no need of a magnet or an external ring.

EXAMPLES OF WOODWORK.

(With Engravings.)

Our Plate XXIX. illustrates the priests' door to the presbytery of Llandaff Cathedral, leading from the chapter-room. It is executed in oak: the furniture is of wrought-iron, gilt, and illuminated in colour, by Skidmore, of Coventry. On the same plate is also the altar-table of the church at Merthyr Mawr, in the county of Glamorgan. It is of oak, carved as shown, with the monogram in the centre.

The illustrations on Plate XXX. give a pair of doors as executed for the west, south, and north doorways to the Church of All Saints, Cwm Avon, Glamorgan. They are in oak, and are fitted with grilles of brass, with plate glass sliding panels behind, the object of which arrangement is to afford means of ventilation which may be closed at pleasure, without obstructing the view into the church or diminishing the light. Also, a door in the screen of the archway between the organ chapel and chancel of the church last named. It is of Memel, varnished, and the furniture is of wrought-iron.

The whole are by Messrs. Prichard and Seddon, diocesan architects for Llandaff; and of Whitehall, London.

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HEALTHY DWELLINGS, AND PREVAILING DEFECTS IN THE HOMES OF THE WORKING CLASSES.*

By Henry Roberts, F.S.A.

Believing that the influence of the Ladies' Sanitary Association cannot be directed to an object of greater importance, I felt bound to comply with the request made, that I would present in a condensed form the experience of more than fifteen years, during which the study of this question, with its practical application at home and abroad, has occupied much of my time. And before doing so, as a proof of cordial sympathy with the objects of the Association I have now the honour to address, it may not be out of place to quote a resolution which was proposed by me at the Congrès International de Bienfaisance, held in Brussels in 1856, and was unanimously adopted by the representatives of about twenty different countries there convened under royal authority:—"The Congress declares that it is of public utility that the working classes be enlightened by every possible means in regard to the improvement and the keeping of their houses in good order. It declares the instruction of the young in the labouring classes ought to comprise all which relates to the cleanliness of their persons and of their dwellings, to the benefits resulting from good ventilation, and the evils arising from humidity. Lastly, it thinks that the study of the science of preserving health is one which ought to be rendered accessible to all."

The condition of "healthy" in regard to dwellings, arises out of that which is either local or structural, and may be said in the majority of instances to be not under the control of the occupants; or else it results from circumstances which they ordinarily have the means of changing.

Among the class of persons whose advantageous position usually gives them the power of choosing a residence, there are however not a few who, either through ignorance or from want of consideration, are manifestly insensible to the evils they expose themselves to in a dwelling unhealthy as to its locality, or deficient as to its sanitary arrangements, until the serious, if not fatal consequences are painfully manifest in the state of their health or that of their family. A single illustration of this fact may be drawn from the last annual report of the Registrar-General, where, amongst other analogous cases referred to, is that of three young ladies, nineteen, eighteen, and fifteen years of age, the daughters of a lieutenant-colonel, who died in the past year at Lyncomb, near Bath, from the effects of imperfect drainage.

Such cases show that the importance of this inquiry is not limited to one class of the community, but that all have a personal interest in knowing what are the conditions essential to a "healthy dwelling." In endeavouring to point them out with precision and brevity, my aim will be to avoid the use of technical terms as much as possible; and with a view to simplify the treatment of the subject it will be considered under the three heads already indicated:—1st, as to that which is local; 2nd, as to that which is structural; and 3rd, as to that which may be distinguished as being mainly, though not wholly, dependent on the occupants of the dwelling.

In regard to Locality.—High and dry situations with a free circulation of air, whether in towns or in the country, are proverbially healthy, whilst those which are low and damp, or surrounded by confined air, are the opposite. Experience afforded by the state of troops when encamped, or when in permanent barracks, or in hospitals, is conclusive on this point. It is on record that the mortality of troops in Jamaica has been diminished from 120 to 20 per 1000 by their removal from the plains to the hills. And it is well known that ague, dysentery, and fever, prevail in localities where the surface of the ground is naturally wet and insufficiently drained, or where there exists an accumulation of decaying matter, of which one sure indication is the presence of an abundance of flies. Dampness of situation is also productive of mental depression, bodily feebleness, and a disposition towards intoxicating drink.

Wherever, therefore, dwellings are built on naturally wet ground it is essential to their being healthy that ample provision be made for draining the soil as well as for ordinary surface drainage, and the carrying off of surplus fluid from the house itself. This necessity is more manifest in the country than it is usually in towns, as their gradual formation and progressive increase have generally been accompanied with surface draining under some form or other. Good surface drainage is however peculiarly necessary in towns built on an uneven surface, as is the case with the metropolis, which has been built on low hills in the midst of an imperfectly reclaimed swamp, and is partially underlaid by a stratum of peat. The lower levels on either side of the Thames, where the drainage has been most inefficient, are well known to have been much more severely visited with the cholera than the higher parts of the metropolis. Dr. Farr tells us that, taking the mean of the cholera epidemic of 1848 and 1854 in London, nearly 15 per 1000 of those living under 10 feet of elevation died to 1 per 1000 of those at the highest elevation; and that if London be divided into terraces of different degrees of elevation, the mortality from an epidemic of cholera is, in round numbers, inversely as the elevation.

The providing efficient means for house drainage, as well as a good surface drainage, is a duty which, in the case of towns, obviously devolves on the public authorities. The consequences of a past neglect of this duty have been recently manifested at Windsor, where the prevalence of fevers and choleraic complaints having led to an investigation, the drainage of the town was found to be very defective; whilst on the contrary, at the Castle, a separate and perfect system of drainage having been provided, no disease existed there.

In house drainage one valuable modern improvement is the use of glazed earthenware tubes, which should invariably be kept as much as possible without the building; and especial care ought to be taken that the pipes which discharge into them are properly trapped, in order that they may not become a medium for the escape of foul air into the dwelling. Cesspools under basement floors have been the cause of sickness and deaths innumerable. During the cholera in 1849, to my knowledge, several cases wholly traceable to this cause occurred in one house. Whenever these latent sources of mischief are discovered they should be removed as quickly as possible. The experience of an eminent sanitary engineer leads me to believe that in many houses of the first magnitude, both in the metropolis and in the country, which are not of recent construction, this evil exists, as well as that of defective drains, causing the ground under the house to become sodden with fetid matter. The gases which originate from these sources and diffuse themselves over the dwelling constitute one of those conditions of local impurity which exercise a powerful influence when the state of the atmosphere is favourable to an outbreak or spread of cholera, fever, or other kindred complaints.

For an ample supply of pure water, one of the most important accessories to a healthy dwelling, the public authorities should in the case of towns be held responsible. The contamination of our rivers, by their being unscrupulously—and at the same time wastefully—made the receptacles of sewage, has rendered them very generally incapable of supplying the neighbouring population with wholesome water. That drawn from wells is not unfrequently impure, though its sparkling appearance and freshness to the taste might lead to the contrary supposition: in towns this is generally caused by an infiltration from some neighbouring drain, cesspool, or other deposit of putrefying matter. Many such instances in the metropolis might be referred to: one was recently mentioned to me by the medical officer to the General Post Office as having been the cause of much internal derangement to several of the *employés* in that establishment, and which had led to his recommending the use of Harrison's moulded carbon filter. In the last report of the Registrar-General reference is made to a well at Sandgate as containing 40·96 grains of impurity per gallon.

Measures recently taken in many places have effected much good in respect both to drainage and to the supply of water. The noble example set by Glasgow especially deserves the highest praise. The purity of the water now abundantly drawn for the supply of that city from Loch Katrine, a distance of 34 miles—and which has involved an outlay of about £1,500,000—may be judged of by the following figures, which represent the total amount of impurity in grains per gallon. In the water supplied to Glasgow from Loch Katrine, 3·16. In the water supplied to London, according to the returns for May last, by the leading companies—Chelsea, 17·84; Grand Junction, 17·95; New River, 18·52; West Middlesex, 20·08; Lambeth, 20·8; Kent, 21·68.

For dwellings in the country good drainage and ready access to pure water are not less essential than they are in towns, and they ought therefore to be made the subject of deliberate investigation before the locality of a dwelling is fixed on.

* Read at the South Kensington Museum, on behalf of the Ladies' Sanitary Association.

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Gravelly soil is unquestionably the most healthy, and next to it one of sand. The embosoming in trees should be avoided: loose soil close to the house is frequently a cause of damp, which might be remedied by a flagging of stones covering a dry drain formed round the building. Care should therefore be bestowed in regard to the surface of the ground round a dwelling, as well as in the selection of a site.

The influence of aspect on the salubrity of a dwelling is too often overlooked: in preference to all others the south should be chosen. In towns the difficulty of obtaining a sunny frontage may frequently be great, if not insurmountable; but the value of having the sun's rays for some portion of the day within the dwelling, especially in the rooms occupied by children or invalids, should never be forgotten. I could point to a large convalescent asylum in the country, so arranged, that the spacious gallery used by the patients for exercise, and where much of their time is spent, is for the greater part of the day without the cheering and warming rays of the sun. I know not whether in this instance it was the case, but such mistakes are very likely to arise out of the prevailing mania for the choice of plans in competition, which are often made by novices and selected by incompetent judges, instead of experienced professional advice being taken.

Diseases which formerly prevailed in particular localities have under the influence of sanitary improvements—such especially as free circulation of fresh air, efficient drainage, and cleanliness in the houses and the persons of their occupants—greatly diminished, and in many instances entirely ceased. This has been the case to a remarkable degree in some of the valleys of Switzerland, where the painful disease in the neck called "goître," and the species of idiocy called "cretinism," formerly prevailed much more extensively than they do now. Remarkable instances have been mentioned to me in that country of the sad consequences to children born and reared in a low and damp ground story, whilst those in the floor above were perfectly healthy.

The beneficial results of sanitary improvements effected in several of our large towns within the past ten years are very manifest. I select three out of nineteen returns which have been obtained. In the metropolis the death-rate has been reduced from 25 in 1000 to about 23; at Croydon the reduction has been from 28 in 1000 to 22·9; and at Liverpool from 39 in 1000 to 27. Knowing however, as we do, that the normal standard is certainly not above 17 in 1000, these results should only be regarded as a proof of our responsibility, and an encouragement to perseverance in the discharge of duty.

How greatly sanitary science has in past days been neglected, even in cases where of all things health ought to be considered of primary importance, may be judged of from an observation made very recently by the Dean of Christchurch, in reference to the removal of Westminster School. "Eton," he said, "is notoriously unhealthy; Winchester is in a swamp; Harrow and Rugby without water."

Before passing on to the next head, I observe, in reference to the local position of buildings in towns, that if the streets around them are of sufficient width, and there is no obstruction to the current of air, dwellings in towns may be better ventilated when they are moderately high, than when they are low and surrounded by higher buildings which exclude a free circulation of air. Nothing can be worse in this respect than the narrow courts terminating in a *cul-de-sac*, which are so numerous in London, and in many other towns, small as well as large.

The vast extent of ground in London covered by low buildings tenanted by the poorer classes will account for the much larger area occupied by houses in proportion to the number of inhabitants than there is in Paris, a fact which may suggest the practicability of increasing the provision of dwellings for working people near their occupations, and at the same time improving their healthiness. As a practical illustration of the advantages which might be derived from the destruction of existing streets of low and miserable tenements, and the replacing them with lofty and suitably arranged dwellings for the working classes, I may refer to two streets, both of them close to New Oxford-street: one on the south side, which leads out of George-street, is the notorious Church-lane; the other is Streatham-street, which lies to the north of New Oxford-street, leading out of a continuation of George-street. Let anyone take the trouble of standing at the end of Church-lane: I do not ask him to go down it, but merely to look; and then to turn his steps to the neighbouring building in Streatham-street, "The Model Houses for Families," where, if he enter the quadrangle and pass along the galleries which give access to the distinct dwellings for fifty-four families, arranged in five fire-proof stories, he will have ocular demonstration of the benefits which may, without pecuniary sacrifice, be placed within reach of the working classes; and he may also, by visiting at the same time the "Model Lodging-house" for 104 single men, in George-street, learn the amount of accommodation and comfort which can be given on the self-supporting principle, for the payment of 4*d.* per night.

Having already noticed, under the head of "Locality," that a free circulation of pure air, an efficient drainage, and an ample supply of good water, are indispensable requisites to a healthy dwelling, we come now to inquire, secondly, what is essential in the structure of a dwelling to its being healthy? 1. It must be dry. 2. Warm. 3. The number and area of its apartments must be in proportion to the number of the occupants, and a due provision be made for a well-ordered family life. 4. It must be well lighted. 5. It must be properly ventilated, and entirely free from noxious vapours of every kind.

1. In order to a house being dry it must stand on a dry foundation; and where this is not otherwise obtainable artificial means should be adopted, either by forming a stratum of concrete, varying in depth according to circumstances, but never less than 12 inches, or by bedding slate in cement, or laying asphalte through the whole thickness of the wall under the floor level. The ground-floor should be raised not less than about 8 inches above the external surface, and where there is no basement story, and the floors are of wood, they should be ventilated by means of air-bricks built in the external walls, the ground being excavated to the depth of not less than 12 inches.

The walls must be weather-proof, of sufficient thickness to secure dryness and warmth. On the facilities for obtaining the material may depend whether brick, stone, or flint, be used; whichever it be, good mortar is essential to dryness. In some places concrete, Pisé, or cob, with an external facing of plaster, may be employed with advantage provided the foundation be dry. Hollow walls conduce greatly to dryness and warmth; and with stone or flint externally, a lining of brick or tile, with a small hollow space left between, is an effectual means of securing both these benefits. A glazing on the external surface of brickwork is an effectual preventive of damp, and it is to be regretted that suitably glazed bricks are not easily to be obtained at a moderate price.

Whenever, for the sake of economy, a ground-floor is laid with brick or tile, it is essential that there should be a dry bed beneath it. Hollow bricks, if well made, may with advantage be used for this purpose, and will prove warm and durable. In some parts of the country lime and sand floors are pretty generally used for cottages, and when properly made are said to last upwards of forty years. Stone or slate is of course preferable to either in places where there is much wear. Bedrooms ought, in our climate, to have boarded floors. It is a false economy to use inferior or unseasoned wood in any part of a dwelling, whilst the cracks and shrinkages caused thereby are often prejudicial to health.

For the covering of roofs tiles are generally found to be warmer in winter and cooler in summer than slates, and requiring less lead are more economical. In some situations however slate more effectually excludes the weather, and is on that account preferable. Projecting eaves should invariably have gutters, to prevent the drip which renders the walls and foundation damp.

How greatly dryness on shipboard, which is the sailor's dwelling, is conducive to health, may be learnt from a fact stated by Capt. Murray, R.N. After being for two years in her Majesty's ship Valorous amongst the icebergs of Labrador, he proceeded thence to the Caraccas and the West India islands on a long cruise, and returned to England "without one casualty, or indeed having a single man on the sick list." After describing the especial care taken to secure perfect dryness in every part of the vessel, Captain Murray says, "I am satisfied that a *dry* ship will always be a healthy one in any climate."

2. The warmth of a dwelling depends not only upon its aspect, its dryness, the materials used, their proper application and substance, as I have already noticed, but also on the structural plan, and particularly on the relative positions of the doors and fire-places, as well as of the windows and spaces for beds; which should be contrived so that the occupants are not exposed to draughts.

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It is surprising that with all our regard for comfort we should not more frequently, by the use of double sashes, which are so commonly used in many parts of the Continent, endeavour to modify the effects of our variable climate, and retain more of the small portion of genial warmth which pases into the room from our wastefully constructed open fire-places. The artificial warming of buildings will be referred to hereafter in connection with ventilation.

3. It is essential to a healthy dwelling that the number and area of the apartments be in proportion to the number of the occupants, and that suitable provision be made for all that appertains to a well-ordered domiciliary life. The question of the amount of space required for health being greatly dependent on efficient ventilation, will be considered hereafter under that head. Suffice it at present to say, that the scale of accommodation in most dwellings depends in a great measure on the means and circumstances of the occupant; as these vary so much, all that I can attempt is to point out the minimum provision which should be made in the country for a labourer's family, consisting of parents and childen of both sexes. There should be a small entrance-lobby, a living-room of not less than 150 feet in area, a scullery of from 60 to 80 feet area, in which there should be a stove or fire-place for use in summer, as well as a copper and sink; there should also be a small pantry. Above should be a parents' bedroom of not less than 100 feet superficial, and two sleeping-rooms for the children, averaging from 70 feet to 80 feet superficial each, with a distinct and independent access. Two of the sleeping rooms at least should have fire-places. There should also be a ventilated and well-drained closet, and suitable receptacles for fuel and for dust. The height of the rooms, in order to their being healthy, should be scarcely less than 8 feet, and even 9 feet would be desirable but for the extra expense. With a view to ventilation the windows should reach nearly to the ceiling, and the upper part be invariably made to open. For examples of such dwellings I may refer to the model cottages for twenty families, built in 1852 and 1853 by the Windsor Royal Society, from plans I had the pleasure of giving to the society; they have continued to be let at rents which, with careful management, have returned from 4 to 5 per cent. net on their cost, clear of all expenses.

To revert again to the essentials in the construction of a healthy dwelling, I add that the smoking of chimneys, if not caused, as it often is, by the want of sufficient air in the apartment, or by bad management in the first lighting, or in the putting on of fuel, generally arises from some defect in the construction of the flue, and not unfrequently from its being too large for insuring a continuous upward current. Nine inches square, or, which is preferable, 11 inches diameter, is a size sufficient for all ordinary chimneys. Especial pains ought to be taken to avoid smoke, an evil which so greatly contaminates the air, and proverbially has but one parallel in the category of domestic grievances. Of Dr. Arnott's smokeless fire-place I shall have occasion to speak hereafter in connection with ventilation.

The use of lead for water-pipes, and especially for cisterns which are to hold drinking water, ought to be dispensed with as much as possible, on account of the injurious effect produced by the chemical action which frequently takes place when the water is soft. Iron, properly varnished, may be substituted for both purposes; and for cisterns slate is a very suitable material. The offensive smell which often proceeds from sinks of ordinary stone, or of lead, renders the substitution either of slate, of glazed stoneware, or of enamelled iron, very desirable, wherever it be practicable.

4. A dwelling to be healthy must be well lighted,—a dark house is not only gloomy and dispiriting, but always unhealthy. We know on high medical authority that "the amount of disease in light rooms as compared with dark ones is vastly less." Light ought to be diffused over the whole dwelling, so that no dark corners be left to invite a deposit of that which is untidy or offensive. Happily, the motive which in time past led so much to an exclusion of the light of heaven no longer exists; and though ages may pass ere the evils resulting from a vicious legislation are entirely swept away, yet the removal of the tax on windows, and of that on glass, must, amidst much to discourage those who have long and zealously laboured in the cause of sanitary amelioration, be regarded as most valuable concessions in its favour.

5. Proper ventilation, efficient warming, and entire freedom from noxious odours, constitute, with the four points already noticed, the sum-total of those essentials to a healthy dwelling which are dependent on locality and structure.

The question of ventilation is of the first importance, though, judging from the neglectful indifference of multitudes, its value is far from being duly appreciated by the educated, and even by some in the scientific classes of the community. Were it otherwise, the closeness perceptible on entering many of their dwellings, the oppressive heat of the rooms, the sickening fustiness in the apartments occupied by the servants, and too frequently in those of the children, would not exist. In halls and lecture-rooms, as well as in schools and other places of public resort, how often does the atmosphere become unbearable through the neglect of an efficient application of known laws! I name but one instance —that of the large room of the Society of Arts on a crowded night. Many others might be added. In hospitals the want of due attention to this important branch of hygienic science has too often led to the aggravation of disease and the destruction of human life. It is recorded of one hospital that the deaths, which before the ventilation were 1 in 6, were after ventilation reduced to 1 in 20.

It is with ordinary dwellings that our observations have chiefly to do, and when we remember the number of hours passed within doors by every human being in a civilised state, it will be manifest that the breathing of vitiated air for so large a portion of the twenty-four hours must be as injurious as living on unwholesome food. A remarkable proof of the influence which ventilation has on health was given some years since at Glasgow. In a block of buildings known as "the Barracks," which contained a population of 500 persons, 57 cases of typhus fever occurred in two months, and within the year there were about 100 cases. A medical gentleman had them ventilated by carrying a pipe from the upper part of each room into the shaft of a neighbouring factory chimney: the result was, that in eight years only four cases of typhus occurred.

The cubical space required to keep a healthy man in full vigour is a question of much importance, and one on which very different opinions have been expressed. Experience gained in poor-houses, dormitories, prisons, &c., has led to the conclusion that from 450 to 500 cubic feet are requisite, and that the ventilation should be such as will cause an entire renewal of the air about once in the hour. Observations made at the model lodging-house in George-street, St. Giles's, which is a confined situation, satisfy me that the cubical space of 535 feet, which is provided in the dormitories of that building for each inmate, is, with proper ventilation, abundantly sufficient to render them healthy: such was proved to be the case even when the cholera raged in the neighbourhood, and had not a single victim out of the 104 men who lodged within its walls. From this fact I think it reasonable to infer that the cause of unhealthiness in the Wellington Barracks, where the cubical space per man allowed in the dormitories is stated to be 500 feet, must be caused not by want of space, but by some other existing evils, particularly defective ventilation, as pointed out in the report to the General Board of Health by the Commission on Warming and Ventilation.

As mistakes with regard to space may create imaginary difficulties, and either impede sanitary reform or cause a serious unnecessary expenditure,* I think it of use to notice an error on this point made in a recent article on Labourers' Homes, in the *Quarterly Review*, where it is stated that the Lodging-house Act requires an allowance of 700 cubic feet per person. On inquiring of the Assistant Commissioner of Police as to the fact, I learned that 30 feet superficial is the space allowed to each lodger in the metropolitan common lodging-houses, the rooms averaging 8 feet high (which is equal to 240 feet cube); and that 50 feet superficial is allowed to each police-constable lodged in a station or

* The report of the Government Commissioners above referred to says, at page 99,—"Under all the circumstances, we would urgently direct the attention of the Minister of War and the Horse Guards to the absolute necessity of providing more room and accommodation for the soldiers in barracks, and instead of 500 cubic feet of space, that 700 to 800 cubic feet should be allowed per man, or, as in the case of the Wellington Barracks, that only ten persons should occupy the space allotted to sixteen; and that these regulations should be enforced as soon as extra space can be provided throughout the whole of the United Kingdom." In a previous part of the report, at page 92, are found the following apposite remarks, which scarcely appear to have emanated from the same mind:—"The continuous removal of impure air as it arises is of very much greater importance than the cubical contents of air in a room.... In the soldiers' rooms, which are constantly occupied, the amount of cubical space can be of very little importance, for, how lofty soever the rooms may be, unless the heated and impure air can pass away, the spaces will soon be occupied by air unfit for respiration, and the greater or less size of the room will only resolve itself into a little more or less time before the air is brought into an impure condition.... The soldiers' rooms are about 12 feet in height: with good ventilation this might be reduced to 11 feet, or even to 10 feet, without disadvantage."

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section house, the rooms on an average being 9 feet high, which is equal to 450 cubic feet.

All dwellings should be so constructed as that they may be everywhere accessible to pure air, and free from stagnation in any part. The state of the surrounding air has necessarily much influence on that within the dwelling; and the renewal of the latter should always be sought from the purest source, instead of the supply being drawn, as it often is, from a low damp situation or a confined internal court. The main practical question is, in what way the air which has become vitiated can be renewed with a supply of pure fresh air, without the creation of a draught injurious to the health. To do this the air must enter copiously but almost imperceptibly, and when used its exit should be both complete and continuous.

Ventilation is of two kinds, natural and artificial; the former being effected by means of windows and doors, with the crevices round them, as well as by chimneys and fire-places, which are important agents in natural ventilation, and may also, by scientific arrangements, be made conducive to an efficient system of artificial ventilation, peculiarly applicable to dwelling-houses.

It must be obvious that improvements easily adopted in new are not always applicable to old buildings; but as far as circumstances allow they should be carried out, from a conviction that pure air is indispensable to a healthy state of body and mind.

Windows properly constructed, made to open at the top as well as below, and suitably placed, afford the most ready means for the natural ventilation of dwellings, besides which are the contrivances of louvres, of perforated glass, zinc, tin, &c. Whenever a fire is lit in a room the lower stratum of air is immediately set in motion; a current of air is established from the crevices round the doors and windows, or from any other opening towards the chimney, whereby much of the vitiated air is carried off. The process of ventilation takes place in a slight degree when there is no fire in the chimney, and therefore bedrooms are much more healthy with a chimney than without.

An independent supply of fresh air may be introduced into most rooms which have a fire-place, by conveying it through a pipe or channel formed under the floor or in the wall, to an air-chamber constructed at the back or sides of the stoves, in order that it should be there warmed before entering the room. The same, or a separate pipe or channel, may also be used for feeding the fire with air, independent of that in the room, for which purpose it should pass out at the cheeks of the stove rather than beneath the grate, which is liable to cause a diffusion of dust in the room. Such an independent supply is calculated to prevent the chimney from smoking, as well as cold draughts passing from the windows and doors to the fire. It also renders chimney ventilating valves more certain in their action than they often are, owing generally to an insufficient draught in the chimney, which causes an emission of smoke into the room. These valves would be invaluable for the discharge of vitiated air, which is their intended purpose, were it not for this occasional ingress of smoke. The most effective means of avoiding that evil is the carrying up an independent flue in close contact with the smoke flue constantly in use: the air within it is by that means rarefied, and the action of the valve rendered more efficient. Tubular flues, made double for this express purpose, are found to answer well, and have the advantage of occupying but little space.

The best remedy for an egress of smoke in cases where the valve is fixed in the chimney flue, is Dr. Arnott's smokeless grate, with the draught duly regulated by a contraction of the vacant space over the fire. These grates have also the advantage of economising fuel considerably.

With regard to the ordinary grates in use, I may here remark that they are alike wasteful of heat and fuel, both of which would be much economised by the substitution of a stove projecting slightly into the room, and combining the chief advantages of Dr. Arnott's ventilating stove with the cheerful open fire-place. I have seen some such stoves in use on the Continent, and believe that the only valid reason against their adoption in England, beyond the force of custom, is the difficulty—not an insurmountable one—of applying them to our fire-places with their ornamental chimney-pieces, &c. In reference to fire-grates generally I would recommend as one of the most useful modern improvements, the forming the back and the lining with fire-brick instead of iron.

The intimate connection between warming and ventilation has led to a digression, in returning from which I would remark that the greatest difficulty to be overcome in all arrangements for natural ventilation which provide an exit for the vitiated air separate from that by which fresh air is introduced, is the securing that it should always thus act, and not become the medium of ingress for cold air, as is often the case on a change of temperature in the apartment, when no artificial means to prevent it are provided. Gas is sometimes used for this purpose in order to rarefy the air. I have successfully applied it within a shaft or tube of wood, placed behind a square of glass. The air enters through perforated zinc, having a fall-down hopper before it. The apartment, or rather series of dormitories, one above the other, thus receive from the same quarter the combined benefits of light and ventilation.

Tubes of wood perforated with holes, or having chinks at the angles, may with advantage be fixed for ventilation in the angles of the ceilings to common rooms, or be carried across the ceiling, in which latter case they have been occasionally used for admitting fresh air, as well as for the exit of vitiated air. These tubes distribute the air more generally, and are not liable to be closed, as is the case with Sheringham's, or the cottage ventilator made by Hart. Where however tubes are not used, the most simple way of introducing fresh air apart from a window ventilator, is by fixing one of the ventilators just named in an external wall near the ceiling, with an air-brick outside. In small rooms with a fire-place this addition to the usual means of changing the air generally suffices to keep them in a healthy state. At the same time it is desirable that there should be an opening for the escape of vitiated air near the ceiling. This is most indispensable in small bedrooms without a fire-place. In some instances it may be effectively done by means of a pipe carried through the roof and bent at the top; in other cases an opening may be made over the door with perforated zinc fitted in. Perforated or ventilating glass may in some situations be used; and it should be remembered, that where openings can be formed on opposite sides of rooms, the air will be most speedily and effectually changed.

Among various devices for effecting ventilation without artificial aid is that of Mr. McKinnell, which has been much used in Glasgow, and lately in England. It combines the admission of fresh air by an outer tube surrounding an inner tube, through which the vitiated air should constantly ascend and make its escape. The tubes are fixed in the centre of the ceiling or roof, and by a broad flange or fan, extending from the inner tube below the level of the ceiling, and reaching beyond the outer tube, the pure air is diffused as it enters.* The certainty of a uniform action is required to render this ventilator perfect; but that is probably unobtainable without some such artificial appliances as I have now to speak of.

Artificial ventilation is ordinarily effected by the action of valves, fans, pumps, screws, furnaces, stoves, or other artificial heat, including gas, and a variety of contrivances whereby air is either drawn out or forced into the apartment. In the one case, the space occupied by the vitiated air which is withdrawn is replaced by an admission of pure air; and in the other the pure air forced into the apartment causes a displacement of the vitiated air, for the escape of which due provision must be made. In both cases a just proportion between the volume of air which ought to enter and that which should be expelled, is necessary; and in order that the fresh air may be adapted for use at all seasons of the year, means must be provided for warming it prior to its distribution in the apartment. The best means for effecting this is by bringing it in contact with heated fire-brick, suitably arranged in stoves or furnaces. When heated iron is used for this purpose the air is liable to be deteriorated, or as commonly said, burnt. Hot water, which is similarly employed, has not this injurious effect.

Nothing can be more inconsistent with a healthy system of warming than those arrangements which provide only for raising the temperature of the air already in the apartment, vitiated as it may be. Such is mostly the case when the German hot-air stove is used, and also when hot water is circulated in pipes through the apartments; but either may be employed with impunity as an auxiliary to an open fire.

The question has been much discussed here, as well as in Paris and Brussels, whether suction or propulsion be preferable as a motive power for effecting the change of air in ventilation, and

* Properly conducted experiments can only decide the practical value of the objection to the admission of fresh air in the upper part of the room, on the ground that the air vitiated by breathing, which ascends in consequence of its relative lightness, is in that case only diluted, and not entirely replaced by pure air. A simple test whereby the deterioration of the air could be readily ascertained is a great desideratum.

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after examining both systems in their practical application, the latter appears to me decidedly preferable, excepting in peculiar cases where the power of suction may be more readily applied. When fresh air is forced into an apartment through suitably placed openings, it becomes more generally diffused than it does when its entrance is dependent on the withdrawal of the vitiated air by means of suction, the tendency of which is to draw the fresh air towards the point of exit, instead of leaving it to disperse and circulate freely. Suction involves the further disadvantage of setting in movement whatever noxious vapours may be within its reach.

My object in giving these latter details, which are mainly applicable to artificial ventilation, would be misunderstood if it were inferred that I would under any circumstances dispense with any ample provision for natural ventilation in dwellings,—at all events till the science be more thoroughly mastered, and its practical application more simplified, than the report of the government Commissioners on Warming and Ventilation, before referred to, would prove it to be.

(To be concluded in our next.)

RESTORATION OF HEXHAM ABBEY CHURCH.

This interesting ecclesiastical structure has just been re-opened after the completion of the extensive restoration which it has recently undergone. Hexham Church dates as far back as the year 678, but the present edifice was founded about the year 1113. Its style is Early English, and it is one of the purest examples of this kind of architecture in the kingdom. It was also celebrated in later days for its beautiful oriel window, a traceried one, with mullions, transoms, and wheel. This window becoming dilapidated, was taken out about thirty years ago, and replaced by a massive Geometrical window: this, however elegant in itself, was quite out of keeping with the rest of the building, A lady-chapel of very ancient date, which had been built against the east end of the chancel, had also fallen into such a state of decay that it could only be used as a lumber-room; while the whole of the interior of the building was crowded with clumsy pews, and the beautiful pillars were disfigured by whitewash.

Mr. W. B. Beaumont, M.P., the lay rector, wishing to have the building restored as nearly as possible to its original condition, entered into an arrangement with the late Bishop of Durham to rebuild the gable, and complete certain other improvements by removing a number of unsightly old buildings which were crowded round the church, provided the public would also assist in effecting various other alterations.

This condition having been complied with, work was commenced. The whole of the pews were removed, the only seats left untouched being the stalls, which are celebrated for the beauty of their wood-carving. The floor was lowered several inches, the columns cleared from colouring, repaired and refaced, and modern wainscot benches placed instead of the old pews. The principal improvement was however in the east gable, which was taken down, and the Geometrical window replaced by one in the original style, and in union with the whole fabric. The principal window consists of six lancets in two tiers of three lights each; the central light in each tier being a little wider than the two side ones, that in the lower tier being of the same height, while the central aperture in the upper tier is considerably higher, rising into the point of the gable. Two smaller lancet windows relieve the wings of the gable, and light the aisles; and the whole are ornamented with splays and nook-shafts, and surmounted by mouldings resting on ornate corbels. Two strong buttresses correspond with the line of clustered pillars in the interior, and from each of these buttresses rises a pinnacle, 25 feet in height, one-third of which is composed of a perforated octagonal turret, while the remaining two-thirds consist of a corresponding octagonal spire terminating in an ornamental capital. Two smaller pinnacles rise from the extreme angles of the wings, finishing in square pointed spires. The remainder of the gable is finished with plain coping, which forms a slightly projecting moulding.

It is intended, as soon as the necessary funds can be raised, to commence the renovation of the transepts; and Mr. Beaumont, who has already expended upwards of £5000 upon the restoration, is ready to assist the committee in this object. The whole of the works have been carried out under the superintendence of Mr. John Dobson, architect, of Newcastle-upon-Tyne.

LIVERPOOL ARCHITECTURAL SOCIETY.

President's Address.

The first meeting of the thirteenth session of the Liverpool Architectural Society was held on the 3rd ult. in the Royal Institution. The President, Mr. James M. Hay, delivered the following inaugural address:—

"Gentlemen,—In addressing you for the first time as President of this Society, I feel that for my election to so high and honourable an office I am indebted more to your kindness than my own merits, and when I call to mind the eminent gentlemen who have preceded me, and remember how efficiently they have filled this chair, I feel my inferiority the more, my ability the less. Without hesitation, however, I throw myself on your indulgence and forbearance, and shall endeavour to catch some enthusiasm from the example of my worthy predecessors.

We have existed as a society for twelve sessions, and in that period have established a high reputation; our present and future solicitude must therefore be to sustain and increase that reputation; for, the moment we cease to advance, that moment have the elements of decay began to operate in our constitution.

The study and advanced knowledge of architecture has ever been confined to a small portion of the community, and it is not wonderful that it should be so when to master even a rudimentary knowledge of the art requires so much time and patience. How much more does it not require to be able to judge of its excellences or its shortcomings, to point out its faults, or suggest their improvement. It is this small portion of the community, this cultivated few, to whom the architect in all his highest efforts addresses himself: they are the leaders of taste, and the tribunal before which he stands or falls; whose approval he covets, whose censure he avoids. Of late years the study of architecture has been greatly promoted; men of the highest literary attainments have enlisted in its service, and devoted their energies to the elucidation of its principles, both in works of deep metaphysical inquiry and those of a more popular form. A greater general interest has been established. This and other architectural societies are partly the result of that interest, and re-act in a further extension of it. The number of architects has increased in much larger proportion than the population; nor am I of those who regard this as a misfortune—on the contrary, it is my conviction that there are still too few, and that much of what passes current as architecture (where every canon of pure taste and sound construction are violated,) is where no architect has been employed. The works in the vernacular style of the present day have been visited with deserved ridicule and severest criticism, but others besides the profession are chargeable with their faults.

It is somewhat difficult to leap forward one hundred years and imagine what posterity will say of the arts in 1860, or to define its critical opinion of the architects of our own time. Still we do form an opinion, which, though necessarily partial and conjectural, may yet be worth while to analyse and record.

We can look back upon the history of our art and trace it from its infancy; we can watch it step by step, as it gradually advanced towards comparative perfection, and then rapidly declined; how it sprang up in other lands, and pursued a similar rise and fall, or became mingled with other streams, and then, again bursting out and spreading into various ramifications, enjoying a greater or less glorious period of existence. But we still observe it in every case obedient to the universal law of progress and decline. It is interesting to embrace the whole in one comprehensive view; it is interesting to examine the leading styles, and the various secondary and tertiary ones proceeding therefrom, to analyse their elements and various relationships. It is not only interesting, it is a portion of knowledge indispensable to the architect, for it is the very groundwork of his art, and essentially necessary to a thorough mastery of its principles.

These remarks have been suggested to my mind by a vivid recollection of Mr. Huggins' Chart of Architectural Styles, exhibited here towards the close of last session. The idea was a happy one of so embodying the entire history of our art, and presenting it to the student at a glance. Its invention cannot but be considered as exceedingly well-timed, for if published it must yield valuable assistance in the study—now of so much importance—of the development and relationship of the various styles of architecture in all times and countries; and not only among the profession, but also among the public at large, and assist in rendering

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architecture a feature of popular education. It is to be hoped that Mr. Huggins will have it published in such a manner that a copy may be had by every member of the profession, and also suspended on the walls of every school and seminary in the kingdom.

The exclusive study of one style will induce a preference for that style; and the result will be a servile copyism alike degrading to the artist and injurious to the art. It is only the mind which is thoroughly imbued with the principles and characteristics of all styles, and who draws his inspiration from every source, that is capable of producing great and original works. His genius is unfettered, for his materials are unlimited; his imagination is more active, for new combinations suggest themselves at every step, and become moulded and re-cast in forms of beauty never before dreamt of. Though familiar with all precedent, he is less bound by it than the student of one style. He sees the same end accomplished in a variety of ways, resulting in various forms of beauty; his ingenuity is thereby stimulated, and his own productions are more likely to exhibit the most excellent qualities of ancient work.

The question then should scarcely exist at the present hour, Are we the patrons and students of one style exclusively, or students of them all? In recent times one style after another has been resuscitated, and become the pet and favourite of both public and profession, and after awhile has been discarded like other favourites, without making any deep or lasting impression on the national mind. If the prevalence of the styles practised in the present day—the Classic or Italian, and Gothic, with their various modifications—be the result of fashion, we may safely predict for them the same transient or evanescent existence. But the revival of these styles rests upon a broader basis and deeper foundation than the breath of fashion, and they each of them exhibit principles or qualities which we dare not sacrifice and must not lose sight of. While the battle of the styles goes on, the great majority of the architects practise in both styles, making their selection according to the object of the building, the nature of the site, or the kind of material at command. We may consider this as a mark of progress, for it indicates a thinking out of the subject from the very beginning. An architect may now draw his inspiration from sources as wide apart as the poles, and introduce forms and features in his design for which no examples exist and no precedent can be cited. This is also a decided mark of progress, for it indicates a consciousness of art-power, which, 'without breaking covenant with the mighty dead,' but estimating at their proper value ancient examples, is yet ready to avow its independence and assert its superiority. This practical freedom is perceptibly changing the expression of our architecture, and giving it a character of its own. Hence the difficulty of giving a name to the style of certain modern structures, beyond indicating their parentage. This is considerably in advance of the period when it was thought a high eulogium to say that 'this building was exceedingly fine, for the portico was an exact copy of one at Rome;' or that 'that church was a splendid example of modern Gothic, for all the details were taken from York Minster.' No true architect is now desirous of his work being mistaken for that of the thirteenth or fourteenth century, or any other period of past history, but rather that it should be the product and bear the impress of his own mind. While there is some reluctance exhibited in the relinquishing certain features which claim the authority of precedent, but are admittedly bad, and also the occasional introduction of others not governed by the purest taste, we may safely conclude that, if we are in the right path, time will purify the one and remove the other. We must also recognise the difficulty of fusing together into one harmonious whole, features pure in themselves but opposed in style; and it is only after repeated experiments and various minds pursuing the same direction that we become reconciled to it.

Liverpool possesses buildings, recently erected or still in course of erection, which exhibit the justice of these remarks, and will serve to illustrate my meaning. In most of these the Classic element is predominant, and forms the groundwork of the style, while a Gothic spirit—Gothic in its widest signification—animates and pervades the whole. These buildings are valuable additions to the town; they stand as meritorious and successful experiments in the present movement, and will stand as landmarks in the advancing tide of architectural development. London and other cities and towns have numerous examples of the same tone and tendency, in which we can imagine their authors saying to themselves—Let us throw style entirely aside; let us design this building according to the principles of art, refusing to admit any one style having exclusive occupation of our minds at the time. In Paris a curious building has just been erected for the Mairie of the First Arrondissement. It is adjacent to the old Gothic church of St. Germain l'Auxerrois, and is a Classic or Renaissance *translation* of that style, even to the many-mullioned and traceried windows. In the new streets and boulevards there is much to interest the architectural student; but nowhere is the genius of the French artist shown to greater advantage than in the completion of the Palace of the Louvre. In conception and general design, well-marked outline, and clearly defined parts, in light and shade—to which the lower arcades so powerfully contribute—in the union of the sculpture with the architecture, and the careful finish of every part, it is a work reflecting the highest honour on the French school.

There is another cause tending to modify design in the present day, and that is the introduction of new materials, or their application to new purposes. No past age was so fertile in all the various scientific and mechanical inventions applicable to the building art. The architect must keep pace with the inventive progress of the age, and try, prove, adopt or reject; and if he is desirous of not remaining entirely dependent on the opinions of others for the adoption of anything new, he must spend much time in inquiries and investigations of this kind.

An interesting question here arises, viz. how should an architect be educated? It is not sufficient that after receiving a good general education he is articled for five or seven years to an architect in full practice,—he thereby certainly becomes acquainted with all the routine of the office, the mechanical practice of preparing drawings, working details, and specifications,—he ought to be following out a course of private study of his own; but he may have no one to direct him, either as to what they should be, their order or arrangement, their relative importance, or the relative time to be spent over each. From the moment however the student has a drawing to make which is not to be a literal copy of one set before him, his reasoning powers come into actual operation; principles of beauty, fitness, utility, proportion, &c. are ever embodied more or less in every drawing, and opportunity is from time to time afforded to the master of pointing out the truths and principles of architecture, and to the pupil of eliciting the same himself. Twelve months or two years would be profitably spent by the student in working with his own hands at one or more of the building trades, or acting as junior clerk of works on some building of importance. It would give him a practical experience only imperfectly gained by any other means. He might then return to the office, where his services would be of increased value, and, after some further experience there, ought to be qualified to practise as an architect.

I do not overlook the importance of travel, whether to the student, the draughtsman, or the busy practitioner. All men should travel, were it for no more than to amuse themselves; but to the architect this amusement may be combined with sound architectural instruction. During the recess I availed myself of the opportunity of having a few weeks' tour on the continent; and, next to a ramble amongst the villages and hamlets of our own land, there is nothing so invigorating to mind and body, or tends so much to restore the equilibrium of the system, as foreign travel. To see with your own eyes those monuments of architectural genius which in past years have been your study, is always a source of enjoyment. Around them are associated some of the happiest moments of your life,—those moments and that period when the love of art was just awakening in your soul, and began to glow with intensest enthusiasm. You walk around them with boyish wonder, and seem to renew an intimacy as with an old friend: much is familiar, much more has all the freshness of novelty. Discarding or correcting false impressions, you are no less gratified in finding out that others which you had previously formed are fully borne out and corroborated by what you see. But the value of travel consists not so much in actually seeing, as in what is suggested. The mind is kept in a state of active excitement,—ideas follow each other with rapidity, but are evanescent, and should be jotted down as they arise, otherwise they are lost.

My excursion included the tour of Mont Blanc, and a small portion of Switzerland, a country which was entirely new to me. With most young architects the desire is to see the antiquities of Greece and Rome, or the mediæval cities of the continent: this is natural, for there are to be found the finest examples of architec-

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tural art; but let them not forget to visit mountain scenery whenever it is in their power to do so.

Ruskin somewhere remarks that the brains of the architect are too much bricked up by a continual residence in large cities, and that he should repair to the mountains to give them air and health and vigour. This repeatedly occurred to my mind in traversing some of those wild mountain passes, where, pausing in the midst of awful solitude and profoundest silence, the whole soul glowing with an indescribable emotion, you feel isolated—alone with the Eternal and the Infinite. Architectural lessons are here taught on the grandest scale. How simple and yet how varied those mountains appear; with what an idea of eternal fixedness they strike the beholder; and yet how animated is the picture, as they seem to play at hide-and-seek with the floating clouds and long-drawn sunbeams. The architect is frequently advised to go to nature to study, but this I apprehend is generally considered to mean the vegetable and floral portion of her domains, where, instead of thoughtlessly repeating the work of past artists, he may study the leaf and flower for himself. Let him not limit his interpretation of the advice to so circumscribed a sphere: to the ardent and faithful student of architecture, nature in these alpine regions has lessons of higher importance to unfold. It is here that he is irresistibly impressed with the elements required to form a grand architectural work—simplicity, boldness of outline, composition, and grouping; an overpowering breadth of light and shade, daring contrast in form, structure, and colour; and, pervading all, an expression of eternal repose. The young student is apt to spend too much time in acquiring a knowledge of mere detail, and the practical architect in its application, forgetful of nobler and more important elements. The purest detail will not atone for the absence of these, and their presence alone will stamp a work with genius and power. There are works in even the most debased style arresting attention and proclaiming this fact. Detail is but the feathers on the butterfly's wing, the foliage on the tree, or the mossy covering on the mountain side; it is that artistic stippling which gives emphasis to some parts and reduces it in others: it bears a certain relationship to the general conception of the work as a whole, but is the last, not the first consideration of architectural design.

These discursive remarks on architectural education arise from a deep conviction that there is a pressing necessity for some regular plan or system being laid down and adopted, the student being left too much to himself to be his own teacher. The diploma question is one which will shortly occupy your attention. An expression of opinion will most probably be requested by the Royal Institute from this society on the question, 'Shall the examination be a voluntary one for the members of the Institute only? or, shall it be a compulsory one on all who in future wish to practise as architects?' If the advantages to the profession be such as are fondly anticipated by the advocates of the diploma, the adoption of the compulsory examination would appear to be the best means of securing them. It would certainly accelerate the preparation of some system of education for general adoption, which of itself could not fail to exercise a beneficial influence on the future well-being of the profession.

The approaching completion and inauguration of the Free Library and Museum are naturally occupying much of public attention. It must be a source of great gratification to Mr. William Brown that he will so soon be in a position to hand over to the authorities and public of Liverpool this enduring monument of his generosity—a generosity that is appreciated by every intelligent mind, for its fruits will be experienced by all classes of the community, in the present as well as in future generations. The gallery to be set apart for scientific and mechanical inventions has a peculiar interest for the members of this society, and it, along with the architectural department of the Library—so much indebted for its valuable contents to the zealous and persevering efforts of the chairman, Mr. Picton—will become an attractive resort for both our students and professional members.

In drawing these observations to a close, I feel that there are many subjects to which I might have alluded, and among others to that of our annual excursion, which was this year to Furness Abbey; but I hope that a description of this visit may yet be supplied by some one who was present on that occasion.

I trust that the session we have now commenced will be a useful and prosperous one. The history of architecture is closely allied to the history of the world and the progress of civilisation; and the architect has no time to fritter away in pursuits which have not a direct or indirect bearing on his art.

Student members,—let all your studies, however extensive, your amusements, however innocent, converge upon the art you have adopted. To master it fully may give free scope and exercise to the most powerful and brilliant intellect. A long life is too short for its accomplishment, and the most eminent architects have only *approximated* to the perfection at which you must aim. The advantages of this society to you are invaluable, and such as many of your seniors never possessed. Besides the lectures to which you have free access, the various competitions to which you are invited are an important feature in your architectural education;—all cannot gain the prize, but all may hope to deserve it; all cannot rise to eminence, but a certain success is never denied to well-directed and persevering effort, based and controlled by high principles of moral rectitude and integrity."

FRENCH AND ENGLISH MACHINERY.

THE Paris correspondent of the *Economist* writes—

"The evidence taken before the French Superior Council of Commerce on the subject of the treaty with England is really of very great interest. Given by practical business men both of England and France, it throws light on the position of the principal trades of the two countries which has never been cast before. In previous letters I have noticed some of the principal facts set forth in it, and here are a few more culled from the reports of the sittings of the 21st, 22nd, 25th and 28th June, which are the last that have been put into type:—French machines for spinning are dearer than those of England, and the reason, according to M. Kœchlin, of Mulhouse, is that the raw material, the fuel, carriage, lighting, models, tools, interest on capital, &c., are all higher in France, while the demand for machinery is less regular, and not large enough to justify the construction of vast establishments. On the whole, M. Kœchlin calculates that such machinery in France costs 310 fr. a ton more than in England; and he and his fellows consequently ask for a protection of 25 or 30 per cent., declaring that, 'with less, competition would be difficult, if not impossible.' But though below England in this description of machinery, it is admitted that in the manufacture of locomotives France has made such extraordinary progress that she can do without any protection on them, and that, in fact, she exports to Spain and Italy in competition with English makers. In the production of carding machines France is being defeated by the English; at Lille, for example, out of five manufactories no fewer than four have been shut up. The builder of engines for steamers asks for 20 or 25 per cent., but would prefer a duty imposed by weight instead of value. Though demanding this protection, one of them, representative of the Forges et Chantiers of the Mediterranean, a great engine-building company, declared that French steam-engines for vessels are quite as good as English, and that considerable quantities of them are exported to Sardinia, Egypt, Rome, Naples, and Russia. As a specimen of what France can do in the building of steam vessels, it was stated that that company in the space of three months built twenty gun-boats, of 20 horse-power each, for China; and that in the course of a year all France can turn out engines of 30,000 horse-power, which would be sufficient for forty vessels. It was alleged as an argument for protection, that whereas in England a screw-engine of 100 horse-power can be constructed for 100,000 fr., one in France cost 120,000 fr. It was stated incidentally that, of late, builders in Glasgow and Newcastle have began constructing an inferior description of engines—'for sale rather than for use.' Touching agricultural machines, it was stated that it was the display at the Exhibition of 1856 of those used in England which first made agriculturists understand their immense utility; and that since then considerable imports from England had been effected. But loud complaints were made that the Customs laws and regulations are so absurdly contrived as to throw on such objects an enormous amount of import duty. As examples it was stated that a Cross-kill roller costing 600 fr. has paid 400 fr. duty; that a boiler for cooking vegetables which cost 28 fr. in Germany, actually paid 147 fr. to the Customs!—also that a Belgian manufacturer of agricultural implements had positively refused to execute an important order, because the 'silly Custom-house regulations of France on such things caused endless trouble and expense.' A large importer of English agricultural machines (a Frenchman) expressed the opinion that 10 per cent. *ad valorem*, or 10 or 12 fr. the 100 kilogs., would be ample protection for French makers; and in

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proof of this he said that haymaking machines on Nicholson's plan can be manufactured in France for 500 fr. though they cost 575 fr. in England. But Count de Kergorlay, a great authority on such matters, declared that, in order to bring machines into general use in French agriculture, the free import of all foreign ones ought to be allowed—at all events for many years to come. After exhausting the inquiry respecting machinery, the Council returned to the iron question; and the well-known M. Talabot once more entered into elaborate arguments to prove that without high protection the French iron trade cannot live. M. Flachat, a very distinguished railway engineer, who was examined on the same matter, showed that ironmasters are subjected to certain grievances under the mining and forest laws, and also as regards the construction of tram-roads to their establishments; the practical consequence of those grievances being to make their iron dearer than it otherwise would be. There can be no objection to granting the ironmasters redress on these points; but assuredly they do not afford any justification for protecting those persons by high import duties, and so impose a heavy tax on the general public. In connection with the iron question, two French engineers, sent specially into England to make inquiries respecting the cost of production, gave much valuable evidence. They, I perceive, bore testimony to the fact that the proprietors of several large ironworks in England not only answered all questions, but offered their books for inspection. The recent sittings of the Council have been directed to the cloth and cotton manufactures."

WROXETER EXCAVATIONS.

THE discoveries hitherto made are: First, the basilica or town hall of the Roman city, an extensive building which, from accidental circumstances, at the commencement of the undertaking the excavation committee were obliged to fill up. Second, the extensive public baths of Uriconium, of the importance of which some notion may be formed when it is stated that this building covers four times the space of the baths discovered at Pompeii. It is the more interesting to be able thus to examine in our own island the public sanitary institutions which were established here by the Romans, at a moment when the question is so much agitated of introducing the same description of baths among our modern population. Third, a building, also of some extent, which there can now be little doubt was a market place. Fourth, a laboratory of some description or other, with the remains of furnaces and other circumstances which lead to the opinion that it was the workshop of an enameller, and this idea seems partly confirmed by a recent and curious discovery. Just within the entrance of this workshop a heap of sixty coins were found, and near them the fragments of a small earthen vessel which had perhaps contained them; among, or close to these, lay a steel button, beautifully ornamented by damascening, and apparently dropped there when it was quite new, and probably made in this identical shop. The coins, which have not yet been fully examined, will give another clue to the exact period when the Roman city was destroyed. Fifth, some buildings between this workshop and the baths, and adjoining the south wall of the basilica, which were very puzzling at first, but further excavation seems to demonstrate that they were public *cloacæ*. All these buildings, with some others which have not been opened, form an extensive square, bounded on the north and south by parallel streets and on the west facing the Forum of the Roman city. It will not be possible to examine the Forum itself, because the modern road occupies the middle of it, but accidental discoveries made in the field on the other side seem to show that it had a large central area, inclosed with short stone pillars, and perhaps rails. On the south of the southern of the two streets the buildings are found to continue along the side of that street, and of another which runs southwardly at right angles to it, and which has a gutter on one side; but it is not at present possible to say whether these are public buildings or private houses.

It will thus be seen that a very interesting, though small, part of this great Roman city has already been brought to light; and any one who has recently visited the Museum in Shrewsbury knows how many objects illustrating the condition and manners of its inhabitants have been deposited there.

WEIGHTS OF BUILDING STONES IN MOST GENERAL USE.

THE following table has been prepared by Mr. C. H. Smith for a government publication, "The Mineral Statistics of Great Britain and Ireland," edited by Mr. Robert Hunt, F.R.S. The various stones named in the table were fair average samples from the respective quarries. In nearly all cases the weights have been determined by two very accurately-squared 6-inch cubes (duplicates) weighed in the state in which the stones are usually employed for masonry; having been merely squared and placed under an open shed, secured from rain, but fully exposed to the atmosphere during several weeks. The density of stones can be correctly ascertained for practical purposes only by some such method as this; for, in the usual mode of taking the specific gravity of such porous bodies in water, the results depend much upon their powers of absorption, which, in the case of building stones, are extremely various; some specimens absorbing only a very small quantity of water and other fluid, whereas certain beds of Caen stone will hold in a cubic foot rather more than 16 lb. of water or above six quarts. A stone may be very porous and absorbent, and yet durable; its durability depending upon the cementing substance which holds the grains together being strong enough to resist the chemical and mechanical actions of wind, rain, sunshine, frost, &c. Not that absorption is a desirable quality. A stone may be comparatively like a sponge, and yet last for ages without any material decay; but if several kinds of stone be equal in every other respect, that which soaks up least water will certainly be most durable.

Name of quarry.	Nearest post town, &c.	Weight per cubic foot. lb	oz.	dr.
Gatton	Reigate	103	1	4
Tisbury	Tisbury, Wilts ...	111	2	4
Coombe Down Lodge ...	Bath	116	0	0
Totternhoe	Dunstable	116	8	0
Calverley	Tunbridge Wells ...	118	1	0
Windrush, soft ...	Burford, Oxfordshire ...	118	2	12
Farleigh Down ...	Bath	122	10	12
Box Hill	Chippenham	123	0	0
Park Quarry	Tixall, Staffordshire ...	124	9	1
Park Quarry	Corby, Lincolnshire ...	125	11	0
Dundry Hill	Bristol	126	2	2
Cadeby	Doncaster	126	9	8
Aislaby	Whitby	126	11	0
Roach Portland (Gorlings)	Weymouth	126	13	13
Steetley, white ...	Worksop	128	3	0
Ketton	Ketton, Rutland ...	128	5	12
Crawbank	Borrowstoness, Linlithgow	129	2	1
Old Down (Doulting) ...	Shepton Mallet, Somerset	130	4	0
Morley Moor	Derby	130	8	9
Steetley, yellow ...	Worksop	130	9	5
Heddon	Newcastle-on-Tyne ...	130	11	12
Longannet	Kincardine	131	11	11
Beer	Axminster	131	12	0
Dunmore Stable ...	Falkirk	132	2	5
Bottom bed Portland (Gorlings)	Weymouth	132	5	7
Duffield Bank... ...	Derby	132	14	12
Hollington	Uttoxeter	133	1	4
Castle's Quarry, Portland	Weymouth	133	6	7
Haydor	Sleaford	133	7	12
Moakery	Corby, Lincolnshire ...	133	8	0
Brodsworth	Doncaster	133	10	8
Pensher	Houghton-le-spring, Durham	134	5	11
Vern Street, Portland ...	Weymouth	134	10	1
Way Croft, Portland ...	Ditto	135	8	13
Humbie, dark ...	Edinburgh	135	13	0
Gatherley Moor ...	Richmond, Yorkshire ...	135	13	9
Windrush, hard ...	Burford, Oxfordshire ...	135	15	0
Hunger Hill	Belper, Deybyshire ...	135	15	4
Taynton	Burford, Oxfordshire ...	135	15	8
Sutton	Bridgend, Glamorgan. ...	136	0	0
Barnack	Stamford	136	12	5
Park Nook	Doncaster	137	3	0
Duke of Hamilton's ...	Linlithgowshire ...	137	4	4
Hildenley	Malton, Yorkshire ...	137	10	7
Huddlestone	Sherburne, ditto ...	137	13	8
Hawksworth Wood ...	Leeds	137	14	12
Duke of Hamilton's ...	Linlithgowshire ...	137	4	4
Roche Abbey ...	Bawtry, Yorkshire ...	139	2	5
Ancaster	Sleaford	139	4	13
Redgate	Wolsingham, Durham ...	139	9	9
Meanwood	Leeds	139	14	0

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Name of quarry.	Nearest post town, &c.	Weight per cubic foot. lb	oz.	dr.
Scullcap, Portland ...	Weymouth	140	1	0
Humbie, light ...	Edinburgh	140	3	8
Stanley	Bewdley, Salop ...	141	7	0
Catcraig	Borrowstoness, Linlithgow	141	11	0
Wass, soft	Thirsk, Yorkshire ...	141	11	1
Craigleith, bed rock ...	Edinburgh	141	12	0
Ham Hill	Yeovil, Somerset ...	141	12	1
Bramley Fall	Leeds	142	3	8
Stainton	Barnard Castle, Durham...	142	8	5
Hookstone	Harrogate	142	10	0
Weetwood	Leeds	143	0	0
Giffneuk	Glasgow	143	14	3
Anston, Norfall Quarry...	South Anston, Yorkshire	144	0	9
Anston, Stone-ends Quarry	Ditto	144	3	8
Duke's Quarries ...	Cromford, Derbyshire ...	144	8	5
Kenton	Newcastle-on-Tyne ...	145	1	0
Victoria	Leeds	145	3	8
Curf, Grove Quarry, Portland	Weymouth	145	9	9
Woodhouse	Mansfield, Nottinghamshire	145	12	4
Craigleith, liver rock ...	Edinburgh	145	14	5
Gun Barrel	Bewdley, Salop ...	146	0	0
Mansfield, white ...	Mansfield, Notts ...	146	9	0
Corby	Corby, Lincolnshire ...	146	11	8
Barbadoes	Chepstow	146	12	5
New Leeds	Leeds	147	8	0
Grove, Portland ...	Weymouth	147	10	11
Darley Dale	Bakewell, Derbyshire ...	148	3	3
Warwick	Huddersfield	148	10	8
Mansfield, red... ...	Mansfield, Notts ...	148	10	9
Amygdaloid	Crediton, Devon ...	149	9	5
Talacre	Holywell, Flintshire ...	150	4	4
Seacombe	Purbeck	151	0	4
Park Spring	Leeds	151	1	12
Chilmark, trough bed ...	Salisbury	151	6	12
Hoyle House, Clough ...	Huddersfield	151	7	1
Chilmark, Penney bed ...	Salisbury	151	9	5
Bolsover Moor ...	Chesterfield	151	11	0
Elland Edge	Halifax	153	4	9
Longwood Edge ...	Huddersfield	153	7	0
Crossland Hill ...	Ditto	155	4	1
Ketton, Rag bed ...	Ketton, Rutland ...	155	10	13
Viney Hill	Colford, Gloucestershire...	155	11	12
Chilmark, hard white bed	Salisbury	157	6	0
Scotgate Head ...	Huddersfield	158	0	0
Hopton Wood ...	Wirksworth, Devon ...	158	7	4
Lochee	Dundee	158	11	0
Auchray	Ditto	158	14	5
Lioch	Ditto	159	3	1
Knockley	Colford, Gloucestershire ...	159	5	4
Mylnefield	Dundee	160	0	13
Munlochy	Munlochy, Ross-shire ...	160	9	11
Glammiss	Forfar	161	2	8
Wass, hard bed ...	Thirsk	162	8	0
Pyotdykes	Dundee, Perthshire ...	162	8	13
Granite, Stirling Hill ...	Stirling	165	14	5
Granite, High Rock ...	Breadalbane	166	0	9
Dylais	Swansea	166	3	12
Kentish Rag	Maidstone	166	9	9
Black Hill, Granite ...	Stirling	166	10	4
Abercarne	Newport	167	15	5
Trebaunws	Swansea	168	1	9
Red Jacket	Ditto	168	2	8
Granite, Dalkey ...	Dublin	169	9	7
Granite, Bars ...	Breadalbane	160	11	5
Cenfas	Swansea	170	2	4
Mumble	Ditto	170	7	0
Black Marble	Kilkenny	171	6	0
Tyree Marble	Hebrides	172	5	0
Franc Banc	Caen, Normandy ...	116	2	0
Banc de 4 Pieds ...	Ditto	118	0	8
Gros Banc	Ditto	122	0	8
Pierre Franche ...	Ditto	123	3	0
Pierre de 30 Pouces ...	Ditto	128	5	0
Ranville	Ditto	142	6	0
Aubigny	Falaise, Normandy ...	150	6	8
Carrara, statuary marble	Tuscany	168	10	5
Carrara, Ravaccione marble	Ditto	169	2	8

In many engineering works the weight of the stone is of the utmost importance, especially for low buildings occasionally under water where there is a rapid current, or where they are subject to the influence of powerful waves; such circumstances will require a heavy stone to be used, because all bodies immerged are reduced in weight by so much as is equal to that of the bulk of water which they displace. The lightest stone that has been found in masses fit for building purposes weighs only about 103 lb. to the cubic foot. Now if such stone were used in sea-water, it would be reduced by about 66 lb., the weight of a cubic foot of sea-water, and therefore it would be like building on land with a material weighing 37 lb. to the foot, or about the weight of the lightest varieties of dry timber. The heaviest building stones that have yet come under observation are the dark grey varieties of sandstone, from the vicinity of Swansea, Abercarne, the Forest of Dean, and the neighbourhood of Dundee, some of which are even heavier than granite, weighing upwards of 170 lb. per cubic foot. There is also remarkably heavy stone in some of the western islands of Scotland, particularly in the island of Tyree, composed of carbonate of lime, with a large quantity of hornblende in small nodules. Such stones are particularly well adapted for docks, harbours, breakwaters, sea embankments, and all other purposes where the violent commotion of water is to be contended against. In situations constantly or alternately under sea-water, sandstone is preferable to limestone, because it is not so liable to be perforated by the *Saxicava rugosa*, the *Pholas*, or other boring mollusca, which frequently honeycomb calcareous stones to the depth of several inches, thus changing a smooth plain face to an extremely rough one, and increasing the risk of the stones being disturbed by the action of the waves, which are more powerful against an irregular surface than a smooth one.

The stone which possesses the least cohesive strength, or that which will crush with less pressure than any other, is nevertheless strong enough when once fixed in a building, for almost all practical purposes. No architectural members have to sustain greater pressure, in proportion to their size, than mullions of large Gothic windows: the tracery in the great north window of Westminster Hall is now executed in Bath stone, which is remarkable for having the least cohesive strength of all the specimens described as experimented upon in the Report on the Stone for the New Houses of Parliament; some of the mullions of that window are less than 9 inches wide, and more than 40 feet high, sustaining not only their own weight, but also that of the whole of the tracery beneath the arch. The eastern window of Carlisle Cathedral, built with a friable red sandstone, is 50 feet high; the mullions are smaller, and the tracery much heavier than that at Westminster; yet in neither of these examples are there any symptoms of crushing. The cohesive strength of stones is never more severely tested than during their conversion by workmen from the rough state to being fixed in their final situation in a building. During these operations iron levers, jacks, lewises, and various other implements are applied, frequently with but little regard for the mechanical violence which a stone will safely bear; and it may, therefore, be considered a useful practical rule that, however soft a stone may be, if it resist the liability of damage until out of the mason's hands, there can be little doubt of its possessing sufficient cohesive strength for any kind of architectural work. If the foundation be insufficient, or any part of the edifice give way, so as to cause an unfair or unequal pressure, a soft stone will, of course yield sooner than a hard one.

MANUFACTURING ART AND MACHINERY.*

THE section of the department of Applied Sciences which it is my province to lecture upon, is one which, although it treats of common things—that is, treats of the preparation and the method of manufacture of things which are in daily use with almost all of us,—and explains constructions and contrivances which are continually being brought under our notice, yet it must be remembered that improvements in arts and machinery have wrought greater changes in the condition of mankind than any other power or influence; and it is the knowledge of these arts and of these contrivances which gives to civilised nations the superiority which they possess over the ruder and less enlightened people of other lands. It is scarcely necessary for me to bring under your notice, as an illustration, the great social changes which have taken place owing to the development of the mineral wealth which we have been enabled to obtain by the scientific

* Abstract of an Introductory Lecture to a course on Manufacturing Art and Machinery, delivered at King's College, London, by Prof. C. Percy Bysshe Shelley, C.E.

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and beautiful improvement by Watt in the steam pumping-engine (which remains to this day nearly as he left it); the changes which have arisen through the formation of railways, of which Stephenson is commonly called the father, and with the theoretical principles of which the name of Moseley is so intimately connected and justly celebrated; of the changes which have resulted owing to the diffusion of literature, which has to a great extent been brought out by the improvements of Cowper in the printing-machine; and lastly, the changes consequent on the invention and improvement of the electric telegraph, which appears, I think, to ordinary minds the greatest marvel of them all, perhaps on account of the rapidity with which the researches of Continental philosophers, of Faraday and of Daniells, have been brought into practice by the work of many minds directed to the same end, and in which the intellect of Wheatstone played so important a part. I am sure that everyone who is in any way connected with King's College must feel proud that four out of the seven distinguished names which I have just mentioned are those of gentlemen who have been professors here; two out of the four are not with us now, but we cannot recall their memories to our minds without feeling that they have, by their individual talents and by their brilliant discoveries and inventions, advanced us as a nation in our national greatness.

To revert more especially to the professional point upon which I have to address you, I will call your attention to a few facts and premises which may be of interest to you. The principle of a given manufacture may be explained to, and is easily understood by, any person of ordinary education; yet it does not follow from such explanation, however perfect it may be, and however thoroughly understood by the person who receives it, that the process can there and then be gone through and put into practice, for there may be many little minute points, many little difficulties of manipulation to be attended to, which can only be ascertained and carried out by a number of years' continual application and training, beginning perhaps from the early infancy of the operative, who will have to devote the greater part of his lifetime to the special handicraft in which he excels.

Labour performed by the hands of man, without any other assistance, would be extremely limited in the usefulness of its application; and in order to carry out any great work some means must be found for uniting the exertions of several men, or else of increasing the power of one man: the combinations and contrivances which effect this unity of exertion or increase of power are called machines.

The labour of cultivating the ground or tilling the earth, which is the earliest form of work with which we are acquainted, requires in its primitive form but little skill and no machinery. Regularity and uniformity in the work are not necessary in turning over the surface of the soil; the rudest and simplest forms of tools may be used; the seed may be scattered by the hand without any external guide or practice; it may be covered with earth in the same manner as it is sown, and requires no further assistance from the labourer. Nature now lends her aid; the highest degree of skill is brought to bear upon the seed: it germinates, sends forth its root, its stems, its leaves, and grows into a thriving plant, which absorbs its nourishment from the earth, the air, and the light; always keeping in truthful balance the atmosphere in which it lives, performing functions, by day and by night, which are continually aiding in supporting the life of the man who sowed the seed from which it sprang. The plant flowers and bears fruit, it yields seed a hundred-fold, and in due time man returns and with his unskilled labour gathers in the produce and prepares it for his sustenance. We cannot help comparing the small amount of skill which is required of the man to perform his part of the work with that unbounded wisdom and intelligence which are displayed in the changes which are wrought in the seed after it is once in the ground. We cannot but admire the Providence exhibited in the admirable contrivances, the delicate functions, the adaptation of every part for the service it has to perform: the eye is gratified by the beauty of the colour of the leaves and of the flowers, and with their variety and graceful outline of form; and the reasoning mind wonders at the economy of material and its perfect distribution. With this evidence before us of our utter incapacity, we cannot help admitting the existence of an All-powerful Hand immeasurably surpassing us, whose works we can but at best attempt to imitate; and the more we study the super-eminent accomplishments of Nature, the more we feel impressed with the shortcomings of our ability in approaching that degree of perfection which is one of its own attributes.

There is not to my mind any labour to which man at his origin could have been appointed which would have given him such a wide field for his intellect, such an unlimited boundary to his inventive faculties, which has formed such a firm basis for the science and theory of the present age, and leads us to put confidence in that higher Power by which all things are created for our good and pleasure, than that of tilling the ground.

Theoretical knowledge alone is not sufficient for those who intend to put the Applied Sciences into practice. To the theoretical knowledge taught in the class-rooms must be added the practical knowledge which is only to be obtained in the laboratory and workshop.

In the laboratory the hand will be trained to manipulate with delicacy; the eye will be taught to distinguish with facility the various changes of colour and the effects of reactions upon the substances under examination; and that all important difference between dirt and cleanliness in experimenting will be better impressed upon the student by one failure through want of attention to it, than by a whole course of lectures on this particular subject. Chemical cleanliness can, I think, only be learnt in the laboratory; and in like manner, that which is technically called the "truth," and the difficulty of approaching it, can only be learnt in the mechanical workshop.

I have casually referred to some of those former students in this department who have distinguished themselves by the important works they have carried into effect in after-life, and I might add to these many more who derived their education from the same source, and who are deserving not only of the highest praise, but of great public commendation, for the assistance they have lent towards the progress of science, and the appliances which they have brought to bear upon the requirements of the age.

THE COMPARATIVE VALUE OF GUTTA-PERCHA AND INDIA-RUBBER EMPLOYED AS INSULATORS FOR SUBAQUEOUS TELEGRAPHIC WIRES.*

By S. W. Silver.

In directing attention to the microscopical characters of a transparent section or film of gutta-percha and of caoutchouc, it may be of interest to follow out in some measure the comparison, and its practical bearings with regard to the employment of these substances as insulators for wires conveying a voltaic current.

The application of india-rubber for the insulation of subaqueous telegraphic wires, in preference to gutta-percha which is now generally used for the purpose, promises to become of the greatest importance to the progress of electro-telegraphy. It is difficult to account for the fact of this application, for which the material is so eminently adapted, having hitherto been so much neglected by telegraphists. Nevertheless, there are perhaps several facts which may be offered in explanation of the want of appreciation with which india-rubber as an insulator has been received in the telegraphic world. Among these causes, one which materially affected the question in the onset is, the comparative difficulty of working the caoutchouc, which cannot, like gutta-percha, be spread upon the wire while in a plastic state. Again, it was supposed, before long circuits and the employment of intense currents had proved the contrary, that the insulating properties of gutta-percha were fully adequate to the requirements of telegraphy. Thus, the manufacture of gutta-percha covered wires having been first initiated, and being subsequently carried on with a considerable amount of success, there was little necessity for innovation or for improvements. It is less easy however to afford an explanation of the extraordinary misapprehensions which have existed with regard to the properties of india-rubber. Although the experiments to verify the insulating qualities of this material are sufficiently simple, and have repeatedly been performed, both in the laboratory and upon a sufficiently extended scale to place their practical importance beyond a doubt, the most erroneous ideas have prevailed upon this subject among telegraph engineers and telegraphists. Thus, in the Telegraph Manual of Col. T. P. Shaffner, a standard work upon telegraphy, published in New York so late as July of last

* Read before the British Association at Oxford.

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year, the following passages occur in the chapter upon Gutta-percha Insulation, affording a curious example of the mistaken notions which have hitherto prevented the general recognition of the value of caoutchouc as an insulating covering for subaqueous wires:—"Gutta-percha is a non-conductor of cold, heat, and electricity, and in its natural state is non-elastic and flexible." It is scarcely necessary, more especially at the present moment, to show that caoutchouc is essentially a non-conductor, both of heat and electricity. It may simply be asserted, on the authority of many eminent names, as well as of the personal experience of all who have practically inquired into the subject, that its insulating properties, at least in the case of subaqueous wires, are far superior to those of gutta-percha. It is evident from several considerations, that the superiority is mainly due to the complete impermeability of the material, resulting from its elasticity and from the absence of all structure in the consolidated gum. Impermeability to the surrounding fluid is one of the most essential conditions in a coating for subaqueous wires, and is to be secured only in a highly elastic substance, and one in which the production of minute pores and fissures in the process of manufacture and under the various strains to which a submarine electric cable is subject during immersion, is obviated by the nature of the material. When this condition of impermeability is obtained, and not till then, should the question of the insulating power of the material in itself be taken into consideration. We have in india-rubber the most perfect example of an elastic body. Its elasticity is exerted and evidenced throughout the extent of any portion of the material we may take for examination. Its particles exist in a state of tension, through which any pore or fissure which may artificially be made becomes closed by the pressure of the surrounding portions of the substance. It is this condition, conjoined with the adhesive nature of the gum, which causes it to set or become consolidated without the formation of the minute pores which exist throughout the fibrous structure of gutta-percha. But independently of these distinctive characteristics of the two bodies, their respective behaviour under the influence of heat is sufficient to account for the difference in the degree of impermeability. When heated with warm or boiling water india-rubber expands, and it contracts as it regains its original temperature; without in either case altering its character as a homogeneous body. Gutta-percha, on the contrary, contracts when immersed in boiling water, its particles in the plastic condition being brought into closer contact; and when cooled it obeys certain structural laws, assuming more or less a fibrous condition, and expanding with the formation of the minute pores which are observable in the microscopic specimens. The connection which is known to exist between the specific insulating power of bodies and their inductive capacity as dielectrics, appears at first sight to involve a contradiction, when it is stated that not only is india-rubber far superior to gutta-percha as an insulator for wires immersed in water, but that its statical induction with a current of given intensity is found to be scarcely half of that which occurs with a wire coated with gutta-percha. The clue to the apparent contradiction, or to the exception which the fact would appear to constitute to the general law, is to be found in the porous structure of the gutta-percha.

In the case of a wire immersed in water, the amount of insulation which can be afforded by any substance depends upon two causes,—first, impermeability to the surrounding fluid, and second, its specific non-conductibility. So long as the wire remains charged, the inductive action through the insulating coating appears to be in the ratio of its specific non-conductibility; and any loss of electricity through leakage will in all cases necessitate the employment of the high-tension currents by which the inductive action and consequent retardation of the signals is augmented.

It is therefore obvious that the impermeability of the insulating covering of submarine wires is at least of equal consequence with its non-conducting nature when tested in the air. Indeed the loss of electricity, by reason of the necessarily imperfect degree of specific non-conductibility of the insulators which have been employed, is so inconsiderable, and the effects of inductive action, constituting the most serious difficulties of the telegraphist, are of such detriment to the efficiency of the line, that it becomes desirable, providing the necessary amount of impermeability may be secured, to employ for the coating of the wire a dielectric of low power, and of which the specific insulating property is imperfect in a corresponding degree. It is more than probable that, if a perfect non-conductor of electricity could be obtained, its employment as a coating for telegraphic wires would be rendered impossible by the reason of the retardation which would be occasioned by the powerful static charge induced in the wire. In practice, the most perfect insulator for submarine wires, having regard to the efficient working of the line, is that which, possessing the greatest degree of impermeability, gives the smallest amount of inductive action. Sufficient has perhaps been said on this subject, if not to prove the value of india-rubber as an insulator, at least to account for what takes place when this proof is sought in actual experimental trial. In experiments with static electricity in air, gutta-percha is found to be a more powerful dielective than caoutchouc; and in this case its insulating property appears therefore more perfect. When wire coated with gutta-percha is first immersed in water, the insulation is generally found to be good; and, satisfied with the result, the experimenter in most instances pays but little regard to the powerful inductive effect by which in practice the signals become retarded; or if this effect is taken into account, the experimenter counteracts it in some degree by the employment of a current of high tension, without being able to observe the deterioration of the coating of the wire by this means and by the gradual permeation of water through the pores which the microscope renders visible.

INDIA-RUBBER.....*versus*.....GUTTA-PERCHA.	
Homogeneous.	Porosity.
Heat, 300°, no effect.	Heat, at 120° or less, pulpy.
Resilient power, very great.—[Taken from tree while alive;—full of nerve and vitality.]	Inert.—[Taken from tree when dead.]
Manufactured without moisture.	Cannot be manufactured without moisture.—[Steam is generated by the subsequent application of heat.]
A puncture closes of itself.	Puncture permanent.
Wire exactly in the centre.	Capable of being indented—indeed flattened.
Liquefies under decomposition.	Crumbles under decomposition.

Note.—The joinings of gutta-percha now made with india-rubber.

In directing attention to caoutchouc and gutta-percha, allusion must be made to the failures in the several attempts to lay successfully for any length of time a means of communication by electricity with distant parts; a careful examination of gutta-percha (the substance in almost universal use) will suggest a cause—its porosity, as well as a large amount of foreign matter; whereas caoutchouc is completely homogeneous, and contains properties sufficient to justify the highest expectations.

Although the subject of submarine telegraphy has become so important in the British dominions, in the colonies, and in America, the causes of the failure do not appear to have attracted either public attention or that of scientific men. A glance at gutta-percha when subjected to the microscope will explain the cause. Caoutchouc appears to have been greatly overlooked: its homogeneous character justifies the assertion that it surpasses in its insulating properties any other material.

THE PALACE OF LINLITHGOW.

THE once magnificent palace of Linlithgow is associated with so many historical reminiscences, that everything connected with that beautiful ruin is interesting. It is traditionally supposed that a Roman settlement once occupied the site of Linlithgow, although the evidence in support of the supposition is by no means conclusive. Roman remains have at different times been discovered here of a character to favour the opinion that it was once a Roman military station. In 1300 a "pele" or tower was erected here by Edward the First, on the site of an older building, which is said to have been a royal residence in the reign of David the First, in the twelfth century. The story of its capture from the English by the stratagem of a Scottish farmer, William Binnoch or Binney, in Edward the First's reign, is familiar. Soon after its capture the castle was demolished by order of Robert Bruce. It was afterwards rebuilt by the English during their possession of Scotland in the minority of David the Second, when it became an occasional royal residence, according to an order of David the Second, who granted "the pele of Linlithgow" to John Cairns, and ordered him "to build it for the king's coming." In all probability, however, the palace of that period

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was little better in size and importance than the ordinary pele-towers that abound in the border counties and elsewhere throughout Scotland; and it is generally conjectured that the south-west portion of the existing building is a fragment of the original palace, and was the nucleus of the more extensive and elaborate structure that was afterwards built. Robert the Second and Robert the Third made the castle of Linlithgow a frequent place of residence; and parliaments were held there in 1388, and again in 1399.

The building, together with the nave of the church adjoining, was destroyed or greatly injured by fire in 1424. James the First but seldom resided at Linlithgow, but a part of the coinage of his reign was minted there; and James the Second, on his marriage with Mary of Gueldres, settled on her as a dower, the lordship of Linlithgow and other lands, valued at 10,000 crowns. It was similarly allotted by James the Third (who, it is supposed, erected the portions of the palace at the north-west angle, known as the king's bed-room and dressing-room) on his marriage with Margaret of Denmark; and, on the marriage of James the Fourth with Margaret of England, the daughter of Henry the Seventh, it again became a jointure house. In this last reign it first became a favourite abode of royalty, and from that time the work of enlargement of the building proceeded steadily and rapidly. The eastern side of the quadrangle, including the magnificent parliament hall, and the elaborately ornamental original entrance to the palace, was built by him. James the Fifth, the son and successor of James the Fourth, was born at Linlithgow, and still further enlarged the palace (his architect being Sir James Hamilton, of Arran), to an extent which induced an expression of the greatest admiration on the part of his second wife, Mary of Guise, when he conducted her thither after their marriage. He probably erected the fourth side of the quadrangle, including the chapel, and removed the principal entrance from the eastern to the southern façade of the palace. On the 7th of December, 1542, the ill-fated Mary Queen of Scots was born here only a few days before the death of her father, one of the apartments on the west side of the quadrangle being still pointed out as the place of her birth. Here her earliest infancy was passed until her removal by her mother to Stirling; and at intervals during the eventful and stormy period of her after-life she occasionally sojourned there. A parliament also was held at Linlithgow in 1545, and a provincial synod of the clergy in 1552. Mary's son, James the Sixth of Scotland, and First of England, completed the building by erecting the north side of the quadrangle, between the years 1617 and 1628, from the designs it is said of Inigo Jones, and on a site of a part of the palace which, being old and ruinous, had fallen down a few years previously; and once more it was assigned as a jointure house to Anne of Denmark on the occasion of her marriage to the king. James held two parliaments here—viz., in 1585 and 1593. His son and successor, Charles the First, paid a visit to Linlithgow in 1633; and in 1646 the great hall was used by the Scottish Estates, in consequence of the terrible prevalence of the plague at Edinburgh. Linlithgow was one of the strongholds of loyalty in Scotland; and in 1662 the "Solemn League and Covenant" was publicly burnt in the market-place.

The last public event of importance in connection with the Palace of Linlithgow was its occupation by Prince Charles Edward in 1745, when the governor's wife, Mrs. Glen-Gordon, an ardent Jacobite, entertained "the Chevalier" with all honour and great magnificence, on which occasion the fountain in the centre of the quadrangle flowed with wine. In the following year, 1746, during the occupation of the palace by General Hawley and his dragoons, the building was either accidentally or purposely set on fire, and the whole edifice was reduced to its present dismantled and ruinous condition. During the war with France towards the close of the last century, it was in contemplation to convert the palace into a place of confinement for prisoners of war, but the good feeling of the Lord President Blair of the Court of Session interposed to prevent what would have been considered as little less than an act of desecration. The palace is now in the possession of the Commissioners of Woods and Forests, by whose efforts for its preservation this most beautiful relic of the architectural antiquities of Scotland may, it is confidently hoped, be long preserved.

The massive pile of building stands on a gentle eminence to the north of the one line of street of which the town of Linlithgow principally consists, and forms a conspicuous object in the vicinity of the Linlithgow Station on the Edinburgh and Glasgow Railway.* It occupies about one acre of ground, and stands on the south bank of the very picturesque sheet of water known as Linlithgow Loch, the superficial area of which is about 154 acres. The original entrance to the palace, erected by James the Fourth, was as before stated on the east side, and the approach thereto was by an avenue of noble trees; but as altered by James the Fifth, the present entrance is on the south side of the building, through a narrow avenue leading from the main street of the town, an alteration which, as it at present exists, is by no means an improvement. The first building that attracts attention is the entrance gatehouse, a detached building erected in the time of James the Fifth, the form of which is a parallelogram, with octagonal turrets at two of the angles, which are loop-holed for purposes of defence. Over the entrance-archway, which is segmental-pointed and has a bold and effective bead and chamfer for the jamb and arch mould, is a string-course with a twisted cable ornament in the upper member of the mouldings, and over this a series of four panels, of good arrangement and design, which are filled with the insignia and mottoes of the orders of the Garter, the Thistle, St. Michael, and the Golden Fleece, as emblems of the sovereigns, Henry the Eighth of England, Francis the First of France, and Charles the Fifth of Germany, who conferred the several orders on the Scottish sovereign. Until the last few years these were much decayed, and scarcely decipherable, but the restoration they have undergone possesses considerable merit, and the execution of the sculpture is full of character and vigour. The roof of the gateway is barrel-shaped, with a longitudinal centre rib, into which seven transverse ribs resting on a moulded string-course, the whole length of the gateway, are mitred. The interior elevation is quite plain, consisting merely of a segmental-pointed archway, similar in width and heighth to that in the front.

After passing this archway the south front of the palace is the first that presents itself. The character of this elevation is plain, but massive and dignified; the principal architectural features being the entrance porch, and a range of five lofty and boldly-designed windows belonging to the chapel of the palace. The south-west angle, which is conjectured to be the oldest portion of the palace, rises above the roof of the central part of this front, and on its eastern face the weather-mould still exists, indicating the original pitch of the roof. The parapet of this south-west tower is corbelled, and at the angles are the usual Scottish circular turrets. The central portion of the front has been battlemented (a part of which still remains), with double corbelling underneath. The upper part of the south-east angle of the front has been entirely destroyed. The entrance porch has a segmental pointed archway, and circular turrets at the angles, originally surmounted in all probability by conical cappings or pinnacles, of which nearly all traces have disappeared. In the centre are the remains of a large sunk panel or niche, in which the royal arms of Scotland have probably been originally inserted. The roof of the porch is barrel-shaped, but, as in many Scottish examples, the ribs are arranged in imitation of groining, the effect being very much the reverse of satisfactory: they spring from moulded corbels, and at their intersection at the apex is a boss sculptured with the Scottish crown and lion rampant.

On the east front the most striking feature is the original entrance in the centre of the façade, where, over a semicircular-headed archway, is a moulded panel, with buttresses in the jambs, in which panel are sculptured the royal arms and crown of Scotland, flanked on either side by angels bearing shields, and the whole surmounted by an angel with outspread wings. At each side of the panel are the grooves for working the portcullis, and, beyond these, two large niches with canopies. Above is a range of square-headed windows, lighting the upper part of the hall, and at the south-east angle of this front is a large window of two lights, the character of the tracery of which is very peculiar. At the north-east angle detached from the building, are the remains of three low circular towers, forming a kind of outwork to the palace, and of earlier date than the rest of the building: they are probably fragments of the fortifications erected here by Edward the First during the period of his stay at Linlithgow. The north front, which faces the loch, differs materially from the others, in the multiplicity of windows introduced in each story. At the north-west angle is an oriel belonging to the apartment

* The town of Linlithgow, with its irregular buildings, crow-stepped gables, armorial shields and inscriptions, has a quaint and picturesque, though somewhat faded aspect. The preparation of leather, said to have been introduced in the time of Cromwell, and the various occupations of tanners, curriers, and shoemakers, form the chief trading occupations of the place.

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known as James the Third's dressing closet (*quære* oratory). Externally it is plain in character, but internally is well groined, as is also the small closet adjoining. The west front is entirely plain and unadorned, and the window openings are small and without ornament. The most picturesque general view of the palace is that from the loch, comprising the north and east fronts.

Returning to the south front and proceeding onwards from the porch through a passage, the roof of which is barrel-shaped with transverse ribs, and a longitudinal centre rib, we now reach the inner quadrangle, the effect of which is exceedingly stately and impressive, and, the northern side in particular, is said to suggest recollections, although on a reduced scale, of the ruins of Heidelberg. The principal feature of this quadrangle, on its eastern side, is the inner façade of the original entrance, which, as already mentioned, was on the eastern front of the palace. The archway, which is semicircular, is surmounted by an enriched hood-mould, which is ogee-shaped at its apex, and carries the pedestal of the centre niche over, on each side of which is a smaller niche; the canopies of all three are much mutilated, but the pedestals are tolerably perfect, and on one of them is a representation of a figure playing on an instrument somewhat akin to the modern Scottish bagpipe. The centre niche, it is said, was filled with a figure of Pope Julius the Second,* and the side niches with figures of cardinals; by some, however, it is supposed that the sculptured occupants of the three niches were typical of the three estates of the realm—the Church in the centre, flanked by the Nobility and Commonalty. Over each niche is the figure of an angel, the centre one with outspread wings and of larger proportions and greater dignity than the two other figures, both of which hold a scroll, in which in all probability were some few words or legend, but which is now entirely obliterated. It is also supposed that the effect of these figures was originally heightened by colour and gilding.

The south side of the quadrangle, which as well as the north side is faced with ashlar, and therein differs from the east and west sides, both of which are merely rubble-fronted, has three stories or ranges of square-headed and traceried windows, of three and four lights; and over the entrance archway into the quadrangle, on this side, are the remains of the pedestal and canopy of a tenantless niche, above which again were three niches, in one of which a figure still remains. In the centre upper niche there still exist the remains of the lily and flower-vase, emblems of the Blessed Virgin. The west side of the quadrangle is comparatively plain and unornamented. The north side was rebuilt by King James the Sixth, and exhibits in its classicality of character a marked difference from the rest of the quadrangle. It is said to have been the work of Inigo Jones. It is five stories in height, and in the centre has an octagonal stair-turret. Most of the windows have pediments, on the apex of which the rose, the thistle, and fleur-de-lys are alternated, and in the tympana the king's initials, and occasionally the date of the erection—1619 and 1620.

In the centre of the quadrangle are the mutilated remains of a large fountain, octagonal in plan, and the detail of which, *rococo* as it is, displays much vigour and boldness in the execution.†

At the four internal angles of the court-yard are circular stair-turrets leading to the upper apartments, lighted by narrow windows, which follow the raking lines of the steps. The newel of the staircase in the north-west corner, is terminated at the top by a moulded capital, from which spring the groin-ribs which form the roof of the staircase. These ribs rest against the wall, on corbels, on which the monogram 'J' and 'M' (James the Fourth and Margaret of England, his queen) are ingeniously interwoven. Above this tower is a groined octagonal chamber, accessible only from the battlements and which is traditionally known as 'Queen's Margaret Bower,' whence she is said to have retreated to bewail the departure of her husband on the ill-fated Flodden expedition. May not the circumstance of its having been a small oratory have given rise to this tradition? It has also been sometimes termed the Tyler or Watchman's Tower, and although the apartment may be considered as of rather too ornate a character for such a purpose, it may have been intended to be used as a warder's guard-room.

The plan of the palace may be characterised generally as a vast quadrangular mass of building with a central open court; and the dimensions of the entire pile are 175 feet from north to south, and 166 feet from east to west. Entering from the south porch, and adjoining it, is an apartment used in all probability as a guard-room, in which are loop-holes commanding a view of the porch. The rest of the south side is occupied with vaulted chambers; those at the south-west corner bearing the appearance of places of confinement, the remainder very probably ordinary domestic apartments. Towards the inner court, a corridor extends nearly the whole of the south side, communicating at the end with the circular stair-turrets; and at the south-east angle there is a passage to the south front of the palace, and thence opposite to a door into the church.

There is a considerable fall in the ground from west to east, of which advantage has been taken to construct a sunk story on the east side of the palace, where, adjacent to the original entrance, is a guard-room, a most dreary apartment, and so dark and gloomy that it is impossible to discover its actual dimensions on first entering. In one corner of this uninviting room is a small trap or funnel, from which there is a nearly perpendicular descent to a lower depth, an oubliette or dungeon, compared with which the guard-room might almost seem a paradise. Through this "shoot" the wretched prisoner was probably precipitated from above; and the terrors of such a place of confinement would be in no small degree augmented by this being the only mode of entry—no other approach existing, and the dungeon itself, with the exception of one very small aperture for ventilation, being totally dark. The rest of the ground-floor apartments on the east side, which are half-sunk below the level of the quadrangle, were used as the kitchens and domestic offices of the palace.

The first floor contains the principal apartments of the palace. On the south side of the quadrangle is the hall; eastward of which, and leading directly from it, is the chapel, 50 feet by 26, occupying the whole height of the building. On its south side are five large single-light windows. On the north side of the chapel is a corridor, which extends the whole length of that side of the quadrangle. This corridor is two stories in height, the two together comprising the entire height of the chapel; and in the upper passage are openings in the wall, possibly to afford the opportunity of witnessing the elevation of the Host at the altar. At the west end of the chapel there was probably a wooden gallery, the corbels to support which still remain. In the east wall of the chapel, on each side of the spot where the altar stood, are two semicircular arched and moulded openings leading into a narrow passage, beyond which was the sacristy. A small lobby leads thence into the great parliament hall or banquetting room, 98 feet by 30, which occupies the entire eastern side of the quadrangle. This must have been a most stately apartment: it is lighted on the east and west sides by a range of windows, placed high up in the wall, in the piers between which are sculptured and moulded corbels, originally supporting the principals of the roof. On the west side, at the level of the windows, was a gallery in the thickness of the wall, extending the whole length of the room, and most likely intended for the accommodation of spectators. Beneath this gallery, also in the thickness of the wall, was a narrow passage, in one part of which the portcullis for the gateway underneath was raised and lowered. The dais was at the south end, where, occupying nearly the entire width of the room, is a magnificent hooded fireplace with three openings; and at the south-east corner of the hall is the large two-light window already referred to, the tracery in the head of which exhibits some remarkable peculiarities of design. At the north-west angle of the hall was the original entrance by a flight of steps from the courtyard below: this is now entirely blocked up, but traces of the archway are still discernible in the quadrangle and on the inside of the wall. A gallery or orchestra existed at this end of the hall; and beyond to the northward is the upper part of the kitchen. On the north side of the quadrangle, above the ground floor, were the royal private apartments, occupying five stories in height, on the principal floor of which is the state dining room, the windows being towards the north overlooking the loch: this portion of the palace, as before mentioned, was rebuilt by James the Sixth. At the north-west angle are the rooms known as King James the Third's bed room and dressing room. The roof of the oriel, previously described, is ribbed in imitation of groining, with a large boss at the intersection of the ribs, the device of which consists of a unicorn under a tree, with the motto *Belle a vouc seule*. At the south-west corner of this apart-

* Pope Julius the Second gave the sword of state to King James the Fifth, which is still preserved among the Scottish regalia at Edinburgh Castle.

† A very skilful reproduction of this design has lately been effected by Mr. R. Matheson, in the fountain that has been erected in front of the Palace of Holyrood, at Edinburgh.

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ment is a trap-door in the floor leading to a small chamber underneath, in which James the Third is said to have concealed himself when threatened with assassination. On the west side of the quadrangle, the principal apartment is that in which the ill-fated Mary Queen of Scots was born: a small staircase in the thickness of the wall connects this room with a vaulted chamber below. The plan of the palace generally is rendered the more complex by the number of concealed closets and small staircases in the thickness of the walls, and on the top of the building there has evidently existed a continuous means of communication from one part to another behind the parapet.

For the foregoing description of the palace of Linlithgow we are indebted to a very excellent work which we have before taken occasion to notice and quote from,—Messrs. Dollman and Jobbins' 'Analysis of Ancient Domestic Architecture,' in which the architectural details of this building are fully illustrated in a series of admirably executed plates, comprising several elevations, plans, sections, and details, which will well repay an examination.

SIXTY YEARS SINCE; OR IMPROVEMENTS IN BUILDING MATERIALS AND CONSTRUCTION DURING THE PRESENT CENTURY.*

By G. R. Burnell, C.E.

At the present day there is prevalent a disposition amongst the younger, and perhaps also amongst the more conspicuous elder, members of the particular branch of the architectural profession cultivated by this Institute, to treat the study of the practical details of their profession with indifference, and to dwell almost exclusively upon the æsthetical portions of their pursuit. A review, however slight, of the great changes effected in the mechanical arts of construction within the lives of some now present, or since the year 1800, may, therefore, have somewhat of the charm of novelty to many; at any rate, the lessons it will afford must be fraught with instruction and interest to all, if properly handled. The particular date to which the review is limited has itself been selected with a definite purpose—viz., in order to allow us to trace the influence of the great revolution in men's minds which marked the close of the eighteenth century, upon even the technical branches of science; for it is certain that any profound agitation of the higher faculties of the human mind must react upon every form in which human activity displays itself. Unquestionably the inhabitants of the civilised world have made greater progress in their political and moral advancement within the last century than they did in any corresponding period of the world's history, notwithstanding the faults and the crimes which have disgraced in turn almost every nation; and so also, to descend from this exalted moral sphere to our own technical pursuits, do I believe that the mechanical arts have made similar progress, and that, especially since 1800, they have been developed with a degree of energy and of success of which mankind had no previous example.

Let us not however in starting be ungrateful to our predecessors. The wonderful progress we have been able to make was in fact prepared by the researches of the philosophers and engineers of the earlier portion of the eighteenth century; and they who are curious in historical parallels may trace, in the feverish energy with which all classes of analytical and physical sciences were cultivated at those periods, the influence of the long peace of Europe which followed the prostration of French power in 1713; and the still more direct influence upon English prosperity which followed the conclusion of the civil wars in 1746. Such men as D'Alembert, Lahire, Borda, Bossut, Coulomb, Bougeur, Clairaut, Lacaille, Camus, Peyronnet, De Cessart, Rogemorte, Lamblardie, &c., in France; as Boyle, Cavendish, Black, Desaguliers, MacClaurin, Robison, Franklin, Maskelyn, Hutton, Watt, Wedgewood, Smeaton, Brindley, in England; Euler, Frisi, Brunnings, Bernouilli, Pallas, Ulloa, and countless other philosophers, mathematicians, and engineers, in Italy, Germany, and other countries, had laboured earnestly and successfully to advance the knowledge of physical and applied sciences. Works such as the bridges of Orleans, Nantes, Neuilly, Tours, the ports of Havre, Treport, Dieppe, the commencement of the great breakwater of Cherbourg, the erection of the Eddystone lighthouse, and the completion of the Bridgewater canal; or, still more remarkably, the first steps in the application of the steam-engine; were surely sufficient to entitle the engineers of the last century to our admiration and respect. Fortunately for us, we have succeeded to a rich heritage, and we have reason to be grateful to our predecessors. But the natural law seems to have held in this case, as in most others—viz., that progress is accelerated by the mere fact of its own existence. "Vires acquirit eundo:" and I hope to show that the present generation of practical philosophers has done its duty in transmitting with increased brilliance the torch it received from the race which so honoured the eighteenth century.

Perhaps the most simple and logical method of treating the subject before us would be to trace the history of the improvements introduced into the separate branches of construction *seriatim*, and, as far as possible, in their chronological order. I propose therefore to call your attention, first to the improvements effected since 1800 in the execution of foundations; secondly to the increased facilities for construction afforded by the introduction of new, and the more perfect study of the capabilities of old, building materials; and thirdly to the increased facilities afforded by the use of new tools and machinery. Of course no one man can pretend to know, or to be able to record, all that has been done in so wide a field; and I therefore at once beg you to excuse, and to supply the defects of, this cursory review.

First: The researches of the geologists of the last century had called the attention of architects and engineers to the study of the strata upon which buildings were to be erected, and the drainage operations carried on by Elkington had led some acute observers to question the correctness of the principles upon which many eminent practitioners then founded their buildings. About the middle of the last century, in fact, Labelye and De Cessart, had given a species of vogue to the method of founding in deep water upon caissons; and the same principle was adopted in executing the foundations of ordinary buildings erected upon soft, compressible ground; for about that period, nearly all the buildings, for instance, erected in the marsh-lands near London, were founded upon timber platforms, in preference (be it observed) to the use of piles, according to the custom of the Dutch. The first great improvement made in this particular branch of construction since 1800 seems to have consisted in the use of concrete, a substance well known to the Roman and to the mediæval architects, but which had been neglected until Vicat's 'Experimental Researches into the qualities of Limes and Cements' had again turned the attention of builders to the application of that class of materials. Vicat seems to have been one of the first persons to use concrete on a large scale, in the foundation of the Bridge of Souillac, and in our own country Sir R. Smirke and Mr. J. Rennie may be considered to have been the revivers of the use of this material. At the present day concrete has entirely superseded all the systems of timber platforms, and in many cases it has equally replaced the use of piles; that is to say, when the area of the bearing surface is very large in comparison with the weight to be supported, and the subjacent foundations are protected against the lateral displacement.

The introduction of the Parker's Roman Cement in 1796 had, to some extent, prepared the way for the use of what may be called monolithic foundation courses, such as were thus obtained by employing concrete. But the greatest advance in this branch of applied physical science was unquestionably due to Vicat, who first successfully expounded to the public in 1818 the principles upon which the setting of lime depended. Since that period other labourers have been in the field, and not only have the qualities of the various natural limestones been carefully studied, but the manufacture of artificial hydraulic limes and cements has assumed an extraordinary degreee of commercial importance. Sir C. Pasley, Messrs. St. Leger, Frost, Hamelin, Aspdin, Blashfield, and at a later period, Messrs. Minard, Kuhlmann, White, and Francis, have in turn increased our resources of this description, and with such success have their labours been attended, that at the present day the artificial hydraulic limes, and the Portland cement have to a great extent superseded the use of natural materials of those descriptions. Amongst the most remarkable instances of the application of the Portland cement may be cited the foundations of the Westminster-bridge, the hearting of the Dover jetties, and the huge, artificial blocks laid upon the sea-slope of the Cherbourg breakwater, to protect the small rubble of the central parts of that wonderful sea-wall; and the principle upon which the use of concrete in foun-

* Read at the Royal Institute of British Architects.

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dations is based, viz., that of supplying a solid, homogeneous mass to receive the superincumbent weight, has, it may here be added, lately been applied in a still more striking manner; for the French engineers have actually constructed some bridges (such as the Petit Pont, the Pont aux Doubles), both of which have arches of about 104 feet span, and the Pont d'Alma, the centre arch of which is 141 feet span, with a rise of one-fifth) of small rubble, bedded in rapidly setting cement, upon the avowed theory that these arches would practically become huge monoliths. They trusted, in fact, to the adhesive powers of the cement, just as Brunel did in the Maidenhead bridge; and they have succeeded, as he did, in accomplishing their object. The execution of the new graving dock at Toulon, entirely of ordinary concrete, poured into sea-water at least 26 feet deep, may also be referred to as an illustration of the boldness and skill of our neighbours in the use of this material, as well as of the great service it is susceptible of rendering when it may be desirable to found structures in deep water. Unfortunately, the study of the properties of the various kinds of lime is not a favourite one in England, and it is no doubt to this peculiarity of our ordinary professional education that we may attribute the comparatively limited use made in this country of concrete as a material of general construction, and its exclusive employment in foundation works. Perhaps the explanation of the preference of cement for hydraulic limes, so common amongst our constructors, may be found in the same neglect of this important material.

The substitution of cast-iron piles and plates for timber piles and sheeting (of which instances may be observed in the wharf wall of the Blackwall railway station, the Adelaide wharf, and the Chelsea and Westminster bridges), may be cited as an illustration of the application of that material to foundation purposes, at least in an indirect manner. But the greatest modifications lately introduced in this detail of construction were, firstly, those by the French engineers subsequently to 1816, in the manner of forming their bridges (by the use of close sheeting, the interior of which was then dredged out and filled in with concrete), instead of the old and expensive method of forming coffer-dams—a method now almost universally exploded on the Continent, though unfortunately some of the leading engineers did not scruple to attack Mr. Page with great personal bitterness, for introducing it into the New Westminster-bridge. Secondly, we may notice the application of Mitchell's screw piles, and the introduction of the Nasmyth and of other descriptions of steam pile-driving machinery. Thirdly, we may quote the introduction of Dr. Potts' system of driving hollow cylinders of metal for the purpose of forming, as it were, permanent masonry piles under the basement courses of a bridge. Fourthly, the idea upon which Coulomb in the last century based a system for executing foundations under water has been considerably modified and extended in the course of the execution of the new Rochester, Saltash, and the Strasburg and Kiel Bridges. In these cases, large hollow cylinders were sunk through the moveable or compressible upper strata to the solid subjacent rock, by the application of machinery for the compression of the air in the cylinders themselves. Descriptions of these very remarkable works may be found in 'Les Annales des Ponts et Chaussées' for May and June 1859; in 'Les Nouvelles Annales de Construction,' November 1858; in the Dictionary of Technical Terms of the Architectural Publication Society; and in a pamphlet by Mr. Hughes, which unfortunately was not published, upon the foundations of Rochester-bridge.

A fifth modification of the method of founding buildings upon compressible subsoils may be here mentioned. It consists in the use of a layer of fine sand, which is prevented from spreading laterally, and extends over the whole surface of the building. In fact, practically, sharp siliceous sand is incompressible, for as its particles have as little cohesion as the molecules of a fluid, a weight brought upon one portion of the surface becomes distributed over the whole, if simply the weight be prevented from piercing the surface, and if the sand be prevented from moving laterally. This method of founding has been adopted in the execution of heavy embankments carried over peat mosses; and I have myself applied it in the erection of some extensive cotton warehouses on the alluvial lands near Havre.

Secondly: About the end of the last century, cast-iron began to be used for building purposes, and the execution of the Coalbrook Dale and Sunderland bridges, the former of which was completed in 1777, from the designs of Thomas Pritchard and Abraham Derby, and the latter from those of Thomas Payne, in 1796. But the general application of this material appears to date from the period when Telford employed it in the construction of the Chirk and Pontycystle aqueducts, the first stone of the latter of which was laid 25th July, 1795, and of the former 17th June, 1796. Telford also, in 1796, commenced the construction of the Buildwas-bridge with an arch of 130 feet span; and subsequently the practical and thereoretical investigations carried on in our own country into the properties of this material by such engineers as Telford, Rennie, Rastrick, Brunel, Stephenson, and by such physicians as Tredgold, Barlow, Navier, and lastly by Willis, Mosely, Morin, and Hodgkinson, have admitted its application in the most varied manner, and on the largest scale, in the forms of girders, voussoirs, pipes of enormous size, railings, and ornamental decoration. The improvements in the science of metallurgy, have, indeed, contributed to bring cast-iron into almost universal use; but it is necessary to remark that the introduction of the hot-blast in the smelting of iron, about 1831, and the method of converting the cinder-iron introduced by Messrs. Hall and Co., has so materially deteriorated the qualities of mercantile cast-iron that considerable discretion must be exercised by the architect engineer in the application of the ordinary formulæ given for its use.

The building arts have benefitted by the improvements in metallurgy in other ways than in the cheapening of cast-iron. Thus, for instance, the facilities afforded by those improvements for the manufacture of rolled plate and angle-iron, have, under the influence of the constantly increasing exigencies of the public, forced architects and engineers to adopt, about 1846, the plate-iron system of girders, with which the names of Stephenson, Fairbairn, Hodgkinson and Clark, will always be connected, as inventors and appliers. Wrought-iron is now also used largely in bridge construction, in the shape of chain and wire suspensions, or in the form of lattice girders, or even as girders avowedly designed to resist efforts of compression; and more lately still, the introduction of Bessemer's system of preparing steel seems likely to modify to some extent the methods of girder and chain structure at present received, for if the powers of resistance of steel so made should prove to be tolerably uniform, its greater elasticity will, in many instances, lead to its substitution for the cheaper, but less elastic, and consequently bulkier, wrought-iron. Again, the diminished cost, since the commencement of this century of some of the other metals, has increased the number of materials at the command of the architect and engineer, for both constructive and ornamental purposes. The preparation and extraction of zinc, copper, and tin, for example, have all been diminished in cost of late years; and consequently the manufacture of their alloys has followed the same direction. The application of platinum, aluminium, and iridium, are as yet too few and too costly for ordinary building purposes; but the alloys of aluminium seem likely, in fine machinery works, to supplant the use of gun-metal entirely. The new methods of preparing lead for mercantile purposes in the form of rolled sheet and drawn pipes, or even in the form of pipes made by hydraulic pressure, and the introduction of the various methods for galvanising iron, have equally increased the resources of the builder since the commencement of the present century. Even as late as 1840, we may add, much cast lead was employed: at the present day none but rolled lead is used.

It may not be here out of place to dwell for a short time upon the reciprocal influence which the arts of locomotion and of construction have exercised upon one another. The execution of the great network of canals led to the discovery of expeditious modes of forming earthen embankments, to the rapid execution of tunnels, and to the application of cast-iron to building purposes. Simultaneously with the establishment of this canal system, the wonderful system of our turnpike and parish roads was being developed—at the same period, be it observed, that the first Imperial Government of France was carrying on the works of the Simplon, Mont Cenis, and Riviera routes. In the course of the execution of these English roads Telford displayed the originality of his genius by the introduction of the suspension principle in bridge building at Menai, Conway, &c., and thus solved the great difficulty of spanning wide openings at a small expense; whilst the execution of Southwark-bridge by Mr. John Rennie, proved the extraordinary capabilities of cast-iron as applied to arches. But it was the railway system which gave the great impulse to the arts of construction, by the compulsory introduction of wrought-iron as the material to be employed in the execution of girder bridges. It may be that some devoted

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admirers of the architectural styles of peculiar epochs may regret the facilities afforded for carrying out trabeated construction, by the discovery of the laws of resistance of wrought-iron girders in the course of the experiments required before attempting the construction of the tubes for the Menai and Conway bridges. There are however, I believe, few practical architects who do not feel, and who do not willingly acknowledge, the debt of gratitude they owe to the illustrious men who have so immeasurably extended the resources of their art.

The introduction of the new building materials has not been limited to the metals alone, for since the Peace of 1815 especially the world has been ransacked to supply our markets. Marbles are brought from the French Pyrenees, Belgium, Italy, Spain, Greece, and Russia; whilst, oddly enough, we as perseveringly neglect the resources our own country affords—as in the cases of the marbles found near Plymouth, in Derbyshire, and in the Isle of Anglesea, and in Ireland. The Caen, Aubigny, and Maltese stones have been used here, sometimes on a large scale, and with tolerable success when proper precautions have been taken, but the more resisting tertiary limestones of the Paris basin, strange to say, have never been introduced. At home our stone merchants have been more active, for since 1800 the great market of London and the west of England has been supplied with numerous varieties of stone previously unknown to our masons. The oolitic series has furnished us the Barnack, Kettering, and Bath stones, to which new railway facilities will soon probably add the Upway and Tisbury varieties of the Portland stone. The magnesian limestone series has supplied the Anston stone, the value of which (in our London atmosphere at least) seems to be more than equivocal. The sandstones from Yorkshire, the millstone grits of Bramley-fall, and the various stones from Craigleith, Arbroath, Dundee, &c., the slates of Bangor, the flag-stones of Caithness, Rockhill, Yorkshire, Arbroath, &c., have all likewise been recently added to our resources, and, judiciously employed, they might immeasurably increase the facilities for the execution of polychromic decoration. The recent introduction of the White Suffolk brick, and of the variously coloured marl and kiln burnt bricks, has naturally acted in the same manner as the introduction of the variously coloured stones above mentioned, or of the asphaltes, the use of which on a large scale dates from 1837.

The same activity has been displayed in the timber trade, and the number of woods at our command has greatly augmented since the Peace of 1815 especially. Fiscal arrangements have however somewhat interfered with the natural course of the timber trade; for until a very recent period there was a differential duty in favour of our colonial produce, which tended to keep foreign woods from our market. There is now however no advantage in the use of Canadian or American baulks, and none but the superior descriptions of red and yellow pine deals are likely to be sold here. Nearly all the fir timber used in England comes from the North of Europe, and, as is universally known, it is of a superior quality to that of the timber formerly brought from America; though unquestionably the new woods imported from that continent, such as the hackmatac, cedar, green-heart, should be exempted from the implicit condemnation contained in this observation. For the two first-named of these woods have great power of resistance to the effects of alternate dryness and moisture; the latter, the green-heart, is said to resist the attacks of the *teredo navalis*, and of other boring worms. Perhaps these newly-introduced woods are more especially adapted to engineering purposes than to those more correctly named as architectural; but the Italian and Prussian oak, the African and Moulmein teak, the bird's-eye maple, the satinwood, and the newly imported Vancouver's Island timber, have placed at our disposal extraordinary facilities for the execution of beautiful architectural details in this class of materials. I would beg to dwell awhile upon the consideration of the last-mentioned wood, not only on account of the great advantages it offers in the execution of constructive details, from the enormous length and scantling it presents (some sticks of this timber being not less than 127 feet long, by 36 inches square at one-third of the length), which render it invaluable for roofing purposes; but also on account of the beauty and clearness of the grain. I have employed it myself for some elaborately panelled wainscoting, and I distinctly state that I never saw any fir timber fit to be compared with it. The workmen who may use this wood will, it may be added, find that it requires that the tools should be kept remarkably sharp, but no other extra precaution need be taken in working it.

It would not be just to dismiss with a merely incidental notice the wonderful improvements lately made in the ornamental ceramic and vitreous arts. The extensive use of stoneware in the manufacture of pipes for house sewers, waterclosets, &c.; of glazed earthenware for tiles, sinks, and numerous other domestic purposes; and of encaustic tiles, Palissy, China, and Parian wares, have for instance enabled the architects to attain new and brilliant effects. Messrs. Minton, Copeland, Davenport, and their colleagues, have indeed nobly carried forward the art so brilliantly inaugurated in the last century by Wedgewood; but perhaps the most decided revolution effected of late years in the details of the arts of construction is the one which has taken place in the manufacture of glass, in consequence of the abolition of the excise duties about twenty years since. The glass formerly used in England was both small in dimension and bad in quality; whereas at the present day the quality and dimensions of mercantile glass are such as to enable the architect to execute any description of ornamental work he may possibly require, so far at least as those materials are concerned. It is to be hoped that our government may profit by the lesson thus taught them, and that they may relieve the manufacturers of paperhangings from the difficulties thrown in their way by the excise upon paper. Perhaps I may be allowed here to digress a little into the region of political economy, and to observe that it is not to be expected that an improvement in the manufacture of paperhangings would immedately follow upon the abolition of the paper duty. It requires some time before the conditions of a manufacture can adapt themselves to new fiscal arrangements; and, as in the case of the repeal of the excise on glass, it was some years before our manufacturers derived the full benefit of the measure; and, as in the case of the repeal of the excise on bricks, little change has yet been effected; so in the case of paperhangings, it may be some years before our manufacturers may recover their ancient position in competition with the manufacturers of other countries.

The science of applied chemistry has, since 1800, rendered service to the arts of construction in other cases than those connected with the manufacture of artificial cements, or with the improvement in metallurgy and the ceramic arts. Thus, the introduction of the oxide of zinc or the sulphate of baryta, as substitutes for the oxide of lead as the base of oil colours: the great improvements lately effected by the able chemists of France and Bavaria, under the guidance of such artists as Ingrès and Cornelius, in the painting on glass; the processes of Kuhlmann and Ransome for the preservation of building stone by the application of soluble silicates; and the processes of Kyan, Margery, Bethell, and others, for the preservation of timber, by the use of salts of mercury or copper, or of creosote; and the discovery and application of the electrotype process by Spencer, may be cited as among the more apparent benefits conferred of late years upon our pursuit by chemistry. I do not dwell upon the technical improvements in the moulding of horn furniture, in the applications of caoutchouc, gutta-percha, leather, or of the textile fabrics; nor do I dwell upon the wonderful change which has been effected of late years in the mode of procuring and distributing artificial light, because these various manufactures are of a character sufficiently distinct to require separate notice. But it must be evident that every one of these improvements in manufactures has acted markedly upon the style and character of many details of the decoration of house interiors especially; at the same time it has enabled us to attain effects which it would, previously to the commencement of this century, have been absurd even to have attempted. The increased number of the mineral and vegetable oils, of varnishes and pigments, lately placed at our service, have likewise exercised a distinct influence upon ornamental decoration.

The *third* branch of the subject before us—viz., the review of the improvements effected in the arts of construction by the use of new tools and machinery, ought, properly speaking, to be divided into two sections, one of which would be devoted to the consideration of the tools used in the manufacture of other tools; and the second to the consideration of the machinery actually employed in building operations. It would however occupy too much of our time were we to dwell upon the principles or the details of wheel and screw cutting, of turning, punching, slotting, and boring engines, important though they be in the history of art; and I propose only to call your attention to the new machinery which comes immediately under the notice of the architect and building engineer. The number of these machines is daily increasing; for the continued rise in the rate of wages,

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the scarcity of labour produced by the extraordinary emigration of late years, and the consequent almost inevitable restlessness and indocility of the labouring classes, have driven the employers of skilled labour to seek to substitute mechanical for manual labour wherever it has been possible so to do. As the architect formerly was expected to know something at least of the names and uses of the tools employed in the various building trades, so now he must understand the general action of the machinery by means of which his designs are carried into effect, and which are employed in the works he is expected to value.

In carpentry, machinery is little used, unless for the purposes of driving piles, or of hoisting or transporting wood. Some years ago I had the honour to call your attention to the former class of engines; and at present I would simply add that at the beginning of the present century the old ringing engine was the only one in use. This was replaced gradually by the heavy monkey worked by the crab; and, subsequently to 1844, by the steam pile driver, by Nasmyth's hammer, and by Dr. Potts' system of pneumatic pressure. For the purposes of hoisting and transporting timber, the first great improvements made since the commencement of this century were those introduced by Mr. J. Rennie, in the mahogany sheds of the West India docks, which have, in fact, served as the types for all the more modern travelling cranes. Mr. Telford introduced some ingenious modifications of both the pit and double crane, in his various canal and dock works; and in some of the more important shipbuilding establishments the Derrick has been latterly applied for the purpose of hoisting long, cumbrous timbers. In ordinary architectural practice however, a "guy pole" and a crab are nearly all the hoisting machinery required for carpenters' work, just as they were "sixty years since."

Since 1830 the application of machinery to the various descriptions of joiners' work has taken place on a much more extensive scale. The circular saw, and the block machinery, established by Sir Mark Brunel at Portsmouth, was the first step in this direction; and it was followed by the general introduction of the frame or pit saw, and of the circular and the veneering saws, now so common. More latterly still, the ploughing, grooving, tenon cutting, planing, moulding, fillistering, and even carving machinery, have been introduced; whilst the system of artificial desiccation has been rendered available for building purposes—with what success it would yet be hard to say. Machinery has likewise been applied to the sawing, working, and polishing of marbles, slates, and stones of a uniform quality; to the making of mortar, the tempering clays for brick and pipe making, the moulding of such bricks and pipes, the grinding of limes and cements, the rolling of metals into various forms, the hoisting of building materials (as exemplified in the New Houses of Parliament, and in the very remarkable structures around the new basins at Marseilles), the execution of earthworks in formations of a tolerably uniform character, and to the execution of artesian borings of great depth. The motive-power adopted for the above description of machinery has varied in accordance with the necessities and the capabilities of the situations where they have been applied; and wind, water, and steam have been pressed into our service. In England the tendency is decidedly to use steam on nearly all occasions in preference to the apparently cheaper, but more uncertain, natural agents. Hydraulic power has latterly been employed with remarkable success in many cases; such, for instance, as the hoisting of the gigantic tubes of the Menai and Saltash bridges, in launching the Great Eastern, &c.; and the facility with which the ordinary unloading operations of the docks are carried on by means of hydraulic machinery would induce us to believe that it might be applied to building materials, when large quantities of work are to be performed in a small space, and in a brief period. In the construction of some railway viaducts lately erected, steam machinery has been used for hoisting the materials; but I am not aware that hydraulic machinery has been so applied.

In some of the branches of an architect's duties (which modern practice seems likely to withdraw from the members of that profession, in order to confide them to the newly-established class of Civil Engineers, but which formerly was considered to be, as I have called it, a "branch of the architect's duties"), viz., the construction of bridges, two minor mechanical improvements may be alluded to as having been introduced since 1840. The first of these is the application of boring machinery to the formation of the passages for the tying-down chains of suspension bridges; to the preparation of the holes for receiving the tubes, subsequently filled in with concrete, intended to replace piles under the body of the structure; and to ascertaining the nature of the subsoil of the intended position of the bridge. The second of these improvements is the one connected with the lowering of the centres of an arch—an operation of the greatest importance in that branch of construction; for if the centres should be removed abruptly, or with a jar, the solidity of the vault they support may be dangerously affected. There have been several notices in the 'Annales des Ponts et Chaussées' on this subject, to which I beg to refer my hearers; at present it may suffice to say that the system which has been most prominently brought forward is the one in which the centres are made to bear on bags filled with dry sand. The escape of the sand is regulated in such a manner as to be under instantaneous control, and the centres are thus eased without shock or jar of any description.

In ordinary building operations very little improvement has been, or could be, made upon the implements formerly used. The shapes of shovels, spades, tools, navvies' barrows, dobbin carts, earth waggons, timber and stone whims, spring carts with straight or cranked axles, carpenters', smiths', or masons' tools, have all, no doubt, been greatly modified to meet the continual demands for rapidity of execution; but it would hardly enter into our province to notice them. Neither would it be worth our while to dwell upon the improvements in, or the applications of, the ordinary Bramah's press, or of the screw-jack; and we can only in passing allude to the ingenious devices adopted by our Transatlantic brethren for transporting bodily the buildings they wish to preserve, and to the cumbrous machinery employed by M. Lebas to raise the Obelisque de Luxor, at Paris, in 1837. Strictly speaking also, attention ought to be called to the wonderful changes which have been superinduced in our modern domestic arrangements by the universal application of the water-closet system, by the improvements in the details of water supply, by the improved methods of heating, lighting, and ventilation, and even by the use of speaking-tubes, bells, and in some cases of the electric telegraph. But the mere enumeration of these adaptations of physical science to the ordinary wants of life is sufficient to show the range of the investigation before us, and the utter impossibility of including the whole of it in one lecture. It may suffice therefore, at present, to say that the tendency of all that is going on around us is to increase the number of the material elements of comfort at our disposal, if only by reason of the facilities they afford for improving the sanitary state of our homes. At the same time, however, all the improvements in the arts of building tend equally to increase the powers of the architect of the present day to produce effects in the æsthetical branch of his pursuit which were physically beyond the reach of his predecessors, devoid as they were of the wonderful facilities offered by the new materials, the new processes, and the new machinery which have been introduced subsequently to "sixty years since." The power of obtaining and handling stones and beams of gigantic dimensions; of spanning great openings by the use of small materials connected by new mechanical processes or by new cements, and of erecting important structures in positions wherein formerly it would have been impossible to attempt any permanent work, have given rise to a spirit of boldness and hardiness of mechanical daring, which must eventually react upon the artistic expression of our age. An attempt was made in the erection of the Crystal Palace to eliminate a style of architecture which should be characteristic of the state of the mechanical arts of the day; and in the Menai Tubular Bridge a structure has been raised, whose simplicity of outline and grandeur of effect approach as near to the character of sublimity as can be conceived. Neither of these structures were, however, faultless as works of art; the Crystal Palaces, both old and new, being, in my opinion, as ugly as they could well have been; but the signal has been given, the path in which we ought to march has been indicated; and if we boldly look forward instead of backward, if we strive to create an architecture of the future, instead of contenting ourselves with an architecture based upon a reproduction of the past, the progress made in the mechanical arts of late years will not remain so sterile as it has been for architecture. One of the first lessons to be learnt by the artists who would seek to make to themselves an abiding reputation by their application of the means and appliances lately placed at their disposal, seems to me to be, that the laws affecting the resistances of the materials themselves require that they should be treated in many cases so very differently from the older ma-

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terials, that it is absurd to attempt to adhere to archæological correctness of detail, or in other words to endeavour strictly to apply the principles of ornamentation of styles which prevailed in other times. I allude especially to the miserable attempts to be seen in our own country, and abroad, to execute Gothic or Grecian designs, such as bridges, colonnades, &c., in cast-iron; because the feeling of logical impropriety must be excited when we look at the pointed arches and the meagre chamfering of what it is the custom to call a Gothic cast-iron bridge; and the incongruity of the intercolumniations of the so-styled Grecian colonnades must always offend an educated eye. In fact, just as the use of the Grecian marbles and of the Roman bricks led those nations respectively to modify the forms of art they had received from other nations, so ought the use of cast and wrought iron, of glass and cement, in our day, to lead us by degrees to eliminate a style characteristic of our generation.

It seems indeed, to me, that the moral to be derived from our cursory review of the improvements made since 1800 in the mechanical arts of construction, is precisely that it behoves us all, engineers and architects, to seek to discover the true spirit in which those improvements should be applied. The materials, machinery and principles of practical execution lately introduced, regarded as elements of art, ought, I think, to be used with reference to the physical and mathematical laws affecting them, rather than with reference to their powers of adaptation to any particular style of architecture. There should be no attempt to produce, by the aid of cast and wrought iron for instance, sham Gothic tracery, with all the joints of the stone ribs elaborately reproduced by marks on the face, such as I have seen in some instances abroad. Cements should not be used with scorings, in order to look like stone; nor should cast-iron columns be painted to look like marble. Each material should be used in the position for which it is best adapted; and should "tell its own tale," honestly and without disguise, in a way to satisfy the judgment of even those who have not the time to seek the hidden explanation of the objects directly before them. Possibly the earnest attempt to bring about this result may cause the quarrels of *Classicists* and *Mediævalists* to fall into comparative insignificance; but candidly, would that be a misfortune? Why need we be always "au char de la raison attelés par derrière?" Must we always be compelled to seek in the practice of the past a justification for the designs we may make, and the system of construction we may adopt, when the whole tendency of our civilisation, and the spirit of the age, would lead us to strike out a path of our own, distinct in its character from those of former times, though of course based upon the æsthetical principles which the experience of ages has confirmed? In the charming opera "La Dame Blanche," one of the characters repeats as a reason for doing some old-fashioned act—"Car c'est ainsi que cela se pratiquoit en Ecosse il y a soixante ans." We, it is true, are little disposed now to seek models from amongst those who practised "sixty years since;" and they themselves could boast of little originality of invention. The architects, engineers, and mechanicians of, and subsequent to that period, have however endowed us with means and appliances which, rightly used, would enable us to leave "our foot-prints on the sands of time," if only we dare to think and reason for ourselves. May we not, therefore, consider that the course we ought to follow should be to strive after the attainment of a style which should be characterised by its mass and simplicity of outline; its boldness and its truth; its strength and sublimity in structures which may be susceptible of that quality; and that we should, in short, adopt Montaigne's sentiment, and seek "nous tenir au massif et vraisemblable?" The effect of the various improvements in the mechanical arts seem to tend, as it were, to efface detail, the excess of which is the defect of most scholastic art of the present day; and at any rate they would give scope to any magnitude of conception the architect or engineer might be inclined to indulge. From what has been done at the Britannia-bridge, the joint railway station at Birmingham, the reading-room of the British Museum, and the Crumlin Viaduct, we may learn that more remains to do before we can flatter ourselves that we have turned to its full artistic use "*the progress made in the mechanical arts of construction since* 1800." We must, in fact, learn to be truly ourselves, before we can fairly consider that we have reaped all the benefit of the changes made of late years upon the mechanical arts which prevailed "'twas sixty years since."

REVIEWS.

Primer of the Art of Illumination for the use of Beginners. By F. Delamotte.—London: E. and F. N. Spon. 1860.

In the little manual before us is comprised whatever is necessary to a thorough acquaintance with the principles of illumination as practised in the olden time, elucidated by a careful reference to ancient manuscripts, chiefly in the British Museum, and accessible to readers. In connection with the latter, the points to be noted while examining each are clearly explained; and this portion of the book forms of itself a valuable compendium of art. The specimens are taken from English, French, Italian, German, and Oriental works, and the reference figures are collated with those in the guide-book of the Museum, so that no difficulty is presented in ascertaining the precise authority under consideration. We have mentioned this as the leading feature in the book, as well as the most useful, unless we except the practical instructions in the method of choosing and mixing the colours, upon the due mastery of which so much of the effect depends. The letterpress is accompanied by an ample series of plates, in gold and polychrome, which do not profess to give varieties of alphabets in their integrity, but exhibit nevertheless the peculiar characteristics of certain letters, which the student can readily extend at pleasure as regards the rest. It will be seen, therefore, that Mr. Delamotte has done good service in issuing his Primer of Illumination. It is a book that will assist rather than supersede the use of the elaborate essays of Shaw and others, with which we have been so long familiar: for these productions, so excellent in their way, usually presume on starting upon more knowledge of the subject than the majority of persons will be found to possess, and they hence, in some degree, fail of the results which their intrinsic merits are really calculated to effect. Our author, on the contrary, imparts just so much instruction on the history and principles of the art as may serve to fix on certain definite bases the wandering and somewhat hazy notions of people on the subject, and enable them, by reference to good examples, to erect their own superstructure on a certain foundation; and just so much instruction in the practical part of the art as may enable them in a great measure to teach themselves how to practise it.

The leading characteristics of the different principles of illumination, as developed during an investigation into specimens of the changes successively introduced, are defined as follows:—

"1st—The component parts of the initial itself are made the subject of ornamention; sometimes by the contortion of a dragon or some other pliable animal into a grotesque parody of the shape of the letter; sometimes by forming it of a combination of geometric figures, resulting from an endless crossing of lines, the whole terminating in heads or other parts of the same sort of creature; sometimes by the introduction of foliage in a more or less integral manner.

2nd.—The ornamentation, oozing over as it were beyond the limits of the letter itself, extends in a straggling manner upwards and downwards, or downwards and along, forming a partial fringe to the corner or margin of the page.

3rd.—The initial regains its simplicity of outline, but is laid upon a cartouche of ornamental work or of diaper work, the species of ornamentation mentioned in No. 2 being nearly detached from the letter, and forming a kind of canopy—or, as it is customary to call it, 'bracket'—over it.

4th.—The bracket is extended all round the page, and becomes an illuminated border. Illustrations, such as scenes, portraits, &c., are introduced within. The initial dwindles, as does the space for the text, which frequently occupies but a tiny islet in the midst of a sea of rich decoration.

The whole of these resolve themselves into two leading principles: the one where the initial itself is the illumination, and its outline and component parts are the subject of treatment. The other, where the initial remains in its simplicity of outline, and the ornamentation is bestowed on what surrounds it, or on that on which it is imposed. . . . .

In furnishing the beginner with some clue to the best styles for study, there is considerable difficulty arising from *l'embarras des richesses*. One of the best modern authorities on the art enumerates no less than nine successive styles, exclusive of the Italian, all of which, with one exception, present distinct features of beauty; and the larger work by the same author presents three times that number of specimens. From such a mass of materials elimination is not easy. Nevertheless, for all the purposes of this elementary work, it need only be necessary to enumerate four leading styles for study, leaving for any future and more advanced work the filling up of the interstices between these four, and the more expanded description of all.

The first may be referred to the earliest centuries of the introduction

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of the art into this country, perhaps from the sixth to the ninth; its leading characteristics, which are rather distinguished by quaintness than beauty, have been well described as 'an artistic and ingenious disposition of interwoven threads, bands, or ribbons, of various colours, upon black or coloured grounds, varied by the introduction of extremely attenuated lizard-like reptiles, birds, and other animals, similarly treated. The initials are frequently of enormous size, and extreme intricacy.' A frequent peculiarity is the practice of surrounding all external outlines with rows of minute red dots.

The second belongs to the tenth and eleventh centuries, and has been already alluded to as the *opus Anglicum*. The general characteristics are, a border to the whole text, constructed of parallel stripes or bars of gold, between and around which a style of foliage, in perfect harmony with the solidity of the framework, intertwines itself in a graceful and quite peculiar manner.

The third may be referred generally to the fourteenth century, when, as has been before remarked, the art reached its culminating point as far as chasteness of design and elegance of execution were concerned. The period has been well denominated 'a great artistic era, when the architecture, the painting, the goldsmith's work, the elaborate productions in enamel, and the illuminator's art, were all in beautiful harmony, being each founded on similar principles of design and composition.' It is not easy to lay down any but a few leading characteristics, as the specimens are as varied in construction as they are in the style of their beauty. One leading feature however is, the profuse use of what are technically called 'ivy leaves,' as an accessory to borders and initials, and which, tastefully handled, produce very much the effect of filagree work; miniatures and miniature scenes, coats of arms, &c., are introduced at the corners of the page, and at proper intervals along the frame border; tiny birds of gay plumage are perched here and there among the foliage; and the conventional acanthus begins to be associated with natural flowers, &c., leading the way to—

The fourth style, or that in which richness and profusion of decoration reached their culminating point. The end of the fifteenth and the beginning of the sixteenth centuries may claim this style, of which—though as of the last, it may be truly said that the varieties are countless—the leading characteristic is the solid border; by which is meant that the foliage, flowers, birds, animals, &c., which hitherto formed an open border with no background, are now as it were strewed about upon a carpet of gold, or of some good background colour, the effect being heightened by the introduction of shading to 'throw up' the objects portrayed.

The Italian style of the fifteenth century, to which alone reference will be here made, is characterised more or less by all the peculiar beauties of the third and fourth styles just described, but, as might have been expected, with a strong admixture of the classic element both in outline, foliage, and general treatment; in fact, it may be described as consisting of these two styles cast in a classical mould.

There is one species of illumination, chiefly applicable to initials, quite unique in its exquisite chasteness, for which we are indebted to Italy. It consists of interlacing branches, quite white, laid upon a parti-coloured floor, the effect being that a different colour appears through every adjoining interstice of the branches. The background is frequently lightened by being strewed over with white dots.

The Oriental style of illumination is principally characterised by a profuse use of filagree work and gold, and by the introduction of numerous exquisitely finished miniatures and miniature pictures, in which it is not uncommon to find the faces drawn on tiny disks of ivory, and attached to the page *in situ*.

Of the character employed in executing the text of an illuminated piece of work it may suffice to point out—first, that it should agree chronologically with the style of illumination adopted; next, that it should harmonise with it in an artistic point of view; and thirdly, that simple styles of character are preferable."

Construction of the Great Victoria Bridge in Canada. By JAMES HODGES, Engineer to Messrs. Peto, Brassey, and Betts, Contractors. London: John Weale. [Second notice.]

From what we have already laid before our readers on the construction of this great work (*ante* page 309), it may be deduced that floating annular, or as in this case quadrilateral, coffer-dams or caissons—called by Mr. Hodges crib-coffers—however excellent and applicable they may be in all cases where there is a bottom too hard or variable for piles to be driven successfully into, and where there is but a moderate depth and current, have been proved to be unmanageable in deep water with a current of seven or eight knots, and where so large an internal space may be necessary as was required for the piers of the Victoria Bridge. They were, it appears, necessarily abandoned for piers 5 and 6.

We have been particular in detailing (*ante* page 312) the different modes sought to be adopted which failed in execution, and the plan which succeeded under Messrs. Brown and Watson (sub-contractors) of constructing crib-coffers, Canadian fashion, on the spot in comparatively quiet water, immediately behind the moorings which had been previously laid down, as already noticed. Under the circumstances of this case, much depended on the position of the moorings, and still more on that of the temporary crib-piers (necessary throughout such work, and particularly in the erection of tubing), which, when waterlogged by the winter's flood, and shifted by it and the shoving of the ice, required a partial lifting in order to replace them; necessitating the removal of a portion of the stone ballasting, at great cost, delay, and difficulty, by divers and by "men working in the water with nippers and hooks," Such ballasting should consist of clay, when, by the withdrawal of a few piles, the current would soon carry away enough of the loading to render the replacing of the crib-mooring or pier in the position required a comparatively easy operation.

In the erection of the piers Nos. 3 to 7, it is stated, that "the steam derrick, constructed expressly for the purpose by Mr. Chaffey, was used" (as shown in Plate 7 of the work before us); and we cannot conceive that a more useful model than one of that simple machine could be presented to either the society of engineers or architects. We quote a few paragraphs from the text, describing the author's mode of working.

"The south abutment was this year (1856) carried up to the tube level. The material for this abutment was conveyed to the work by the tramway upon cribs put down last year, and now extended to Nos. 24 and 23 piers. In the rear of the abutment, upon the cribwork of the old dam, which was still in place, sidings were laid, into which the trucks carrying the stone for the work were shunted.

Gawntrees, at right angles to the line of the bridge, carrying a series of travellers covering the whole length of the work, were extended over these sidings, and by this arrangement the stone was taken immediately from the trucks to any part of the work. Common travellers were used both for hoisting and setting; a shaft, running the whole length of the abutment, worked by a belt from a small engine fixed below, had gearings attached to it (in each of the traveller spans) driving sockets, into which the spindles of the hoisting-jenny fitted. The men working the traveller had merely to lift the stone till it cleared the truck, then to move the jenny, and place the spindle into the socket, turn on the power, and when the stone was hoisted sufficiently high remove the traveller to the place where it was required. All the hoisting was done by this simple contrivance; and as manual labour for setting the stone was generally preferred, this arrangement was used throughout the work, and in all instances where hoisting by travellers was required."

Allusion is here made, and naturally enough, to the difficulty in the limited Canadian season for masonry, practically reduced to four months, that presented itself to the execution of such a quantity of work, where no service-ground existed at any of the piers for the stacking or sorting of masonry. The quantity of material used in the season of 1856 seems almost incredible, but we insert verbatim Mr. Hodges' returns, by which it appears that something like a thousand tons of stone per day for the sixteen weeks was used, and of timber about seventy tons.

"The amount of material used in the work this season (1856) was

Masonry	879,120 cubic feet
Puddle clay	13,223 cubic yards
Timber	344,450 feet
Stone for weighting crib	11,793 tons.

Daily consumption:—

Masonry	9,157 cubic feet
Puddle clay	183 cubic yards
Timber	2,865 feet
Loose stone	123 tons."

The practicability and general utility of floating coffers under controllable circumstances was further proved in the season of 1857, by that used at No. 7 pier having been cleared, pumped out, moved to and used at pier No. 18; but for other four piers the dams had to be constructed on the spot, corroborating the observations we have made. From the experience gained in the construction of this bridge, it appears, that from the liability to disturbance of the mooring cribs, it would have been probably desirable to have secured them to the bottom by iron drills, in the same way as the coffers themselves were.

The delays occasioned by the numerous difficulties overcome and that still had to be struggled against, the shortness of the working season, and the desire to render the bridge available at the earliest possible period, led to the adoption of a mode of laying the stone without mortar, on slips of asphalted felt 3 inches wide, which admitted of external pointing, and internal grouting by flues left for the purpose, when the frost was entirely out of the stone, the work thus becoming one solid mass.

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In 1857 the erection of the tubing commenced; and here we must let Mr. Hodges again speak for himself.

"I now come to describe a portion of our operations wholly different from the operations of any preceding period. Our works had previously been limited to the erection of the piers to carry the tubes, but this year we were in a position to commence the tubes themselves. No. 1 tube was placed together in the course of this season. The staging was constructed with scows 60 feet by 20 feet, which were moored in position, scuttled, and kept in place by piles sliding in grooves in the manner described for caissons or floating-dams. These piles, when fairly fitted to the rock, were bolted to the sides of the scows, and the tops levelled to receive the sills upon which the framing carrying the truss and platform were erected. Upon the lower chords of the truss (constructed upon the Howe principle) were laid timbers, forming a platform 24 feet in width, closely planked with 3-inch deals. The upper chords, with some slight framing to adjust the height, carried rails, upon which were moved the travellers used for erecting the tubes. The iron was brought directly from the workshops to the platform upon a truck, and with these facilities no difficulty was experienced in putting the tube together.

The platform was kept about 3 feet to 3 ft. 6 in. below the under-side of tube level. Three lines of longitudinal timbers were laid the whole length of the opening, upon which were placed transverse pieces of timber, 12 ins. by 8 ins., at intervals corresponding with the keelsons of tube—say 7 feet apart. These transverse pieces were upon packings, each being adjusted by means of oak wedges. The transverse timbers being all laid down and roughly adjusted as to level, ranging lines were carefully strained on each side of the tube, to which the iron plates forming the bottom of the tube were accurately laid.

By means of screw-bolts, held firmly together till the whole of the bottom was plated, the rivet-holes in the various thicknesses of plates were brought together as accurately as possible. Every hole in which there was not a bolt was rimered by a tool to exactly the size of the rivets by which the work was to be fastened together. As the rimering proceeded the riveting followed; and when it was so far advanced that the bolts holding the plates together were no longer required, they were removed, the holes rimered, and rivets put in. This was continued till the whole of the bottom was completed, and the keelson bars, &c., in place."

When the bottom of the tube was formed of five or six thicknesses of plates, as was frequently the case, as the holes previously punched could not be brought exactly fair, it was found necessary to "rimer" them; the readier mode, as the workmen found it, of making them large enough by means of steel pins driven by heavy hammers, having been properly objected to. Holes so widened are always found on close examination to be torn or burst star-fashion, greatly weakening the sheet of iron so acted on. The best mode in such cases, as suggested by Mr. Hodges, is to have the holes punched rather smaller than the rivets to be used, and then every hole to be systematically rimered to the exact size of the rivets.

Although the tubes were joined in pairs over the fixed bearings, they were not constructed upon the principle of continuous beams; and therefore it was necessary to allow each separate tube to take the full deflection due to its weight previous to the junction being made. They were therefore not joined until ten days after all the wedges had been struck. For the camber, subsidence during construction, and deflection of the tubes, the reader is referred to the accompanying table, which we quote from the Appendix. We also reprint here with pleasure a few lines from Mr. Hodges' book (page 45), showing that the work never was allowed to want the watchful eye and experienced precaution of the late Robert Stephenson.

"It may probably be thought by many that the stagings used in this work were unnecessarily heavy and costly. Under ordinary circumstances they would be so; but it must be borne in mind that any failure or subsidence during the progress of construction would have caused so much delay, as to have rendered the loss of some of the tubes by the approach of winter almost inevitable. Moreover, it was felt that with thin plates, without cells to either top or bottom, unless the staging were made perfectly rigid the tubes could not be riveted together and finished with any degree of accuracy. This was pointed out to the writer by the late Mr. Robert Stephenson before the work commenced. That lamented gentleman more than once impressed upon him the importance of this precaution, and experience amply established the wisdom of his observations."

The year 1858 opened with the conviction that, after the most strenuous efforts and all the precaution gained by experience, security could not be obtained for crib-work or dams against the great shoving power of the ice, particularly as that season it broke up without the rise of water which it was calculated would have carried the ice over the cribs and dams. "The whole of the cribs at Nos. 14, 15, and 16, and three of those at Nos. 12 and 13, were found to have been displaced."

Statement showing Cambers to which Tubes were laid, Subsidence during construction, Deflection of Tubes, &c.

No. of Tube.	Camber of bottom when laid.	Subsidence during construction.	Camber before wedges were struck.	Deflection due to weight of tube.	Camber retained after wedges were struck.	Camber, 10 Dec. 1859 before testing, with permanent way laid and roof on.
	Inches	Inches	Inches	Inches	Inches	Inches
1	3	1¾	1¼	2¼	—1	—1¼
2	5¼	1⅛	3⅞	2⅝	+1⅛	+1
3	4⅛	⅜	4	1¾	+2⅛	+1⅛
4	4⅜	0	4⅜	2⅛	+2¼	+1⅛
5	4⅛	¼	4¼	2⅜	+1⅞	+1⅛
6	4⅜	0	4⅜	2⅛	+2	+1¼
7	4⅜	1⅜	3	2¼	+ ⅜	—
8	4⅜	1¼	3⅛	4	— ⅜	— ⅜
9	4⅜	2¼	2⅛	2⅜	— ¼	— ¼
10	4⅜	1⅜	3	2⅛	— ⅛	—1⅛
11	4⅜	1¼	3⅛	3⅜	— ¼	+
12	4⅜	2	2⅜	3¼	— ⅛	— ⅜
Centre span	6	1⅛	4⅛	7⅛	—3	—4
14	4⅜	2¼	2⅛	2⅜	— ¼	— ¼
15	4⅜	2¼	2⅛	3⅜	—1¼	—1¼
16	4⅜	0	4⅜	3⅛	+1¼	+
17	4⅜	3⅛	1¼	1¼	0	—
18	4⅜	1⅛	3⅛	3⅛	+ ⅛	+ ⅛
19	4⅜	3⅜	1	2⅛	—1⅛	—1⅜
20	4⅛	⅜	3¾	2⅝	+1⅛	+1
21	4⅛	0	4⅛	3⅜	+1¼	+1¼
22	4⅜	0	4⅜	2⅛	+2⅛	+2⅜
23	4⅛	⅛	4	2	+2⅛	+1⅜
24	4⅛	⅜	3¾	2⅜	+1⅛	+ ⅜
25	6	⅜	5⅝	3⅛	+1⅞	+2¼

The succeeding pages forcibly record what English perseverance can do under enormous difficulties, and will well repay a perusal: the inspection by the divers of the waterlogged puddle-chambers, the dredging, and the "inky" springs breaking out, with the provision for an inner puddle-chamber, are all excellent engineering lessons, not to be thrown away again.

"In the month of June of this year, anxious deliberations took place as to the possibility of getting the bridge finished and ready for opening by the end of 1859. 'Could it be accomplished?' was the question anxiously propounded by the vice-president of the company, Mr. T. E. Blackwell. Upon mature consideration an affirmative answer was given by the contractors; and it was decided that the attempt should be made. From that day the greatest activity prevailed, and every one seemed animated with the desire to accomplish the work.

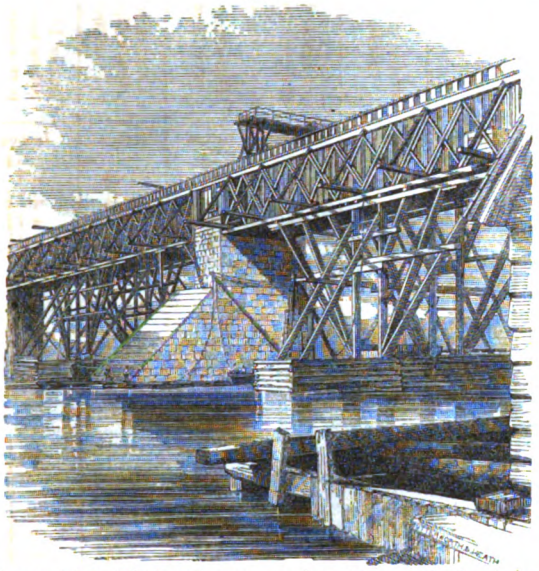
In consequence of this new arrangement, No. 10 dam was commenced on the 28th June and completed on the 24th September. The masonry, which commenced on the 7th of October, was completed on the 30th of November following. With this pier very little difficulty was experienced. Every precaution that experience pointed out was taken to insure success, and fortunately everything turned out right. But when it is considered that in five months 70,000 feet of timber had to be framed into cribs, and sunk in a current running six miles per hour, for which 4870 tons of loose stone were required, 29,620 feet of piles were driven, 2500 yards of puddle-clay put in, 88,830 cubic feet of masonry set (equal, from the time it was commenced to completion, to 1890 cubic feet for every working day), in addition to which machinery had to be put up for pumping, hoisting, excavating, pile-driving, &c., it will be evident that much must have depended on good fortune, and likewise that the work could not have been done with anything like ordinary exertion. . . . During this season eleven tubes were erected, the first being No. 25, the scaffold for which was supported in the middle upon a temporary pier of crib-work, built sufficiently strong to stand against the ice shoves (see Fig. 1). This staging standing well, the erection of the tube was commenced on the 13th of January. It was completed on the 31st of March, the wedges being struck before the ice shovings took place. The erection of tubes upon good substantial scaffolding where no subsidence can take place is so simple a work, that any other description than that given for No. 1 is unnecessary. The whole of those erected this season were done in precisely the same way. . . . .

The whole of the ironwork for the tubes was prepared at the Canada Works, Birkenhead, where a plan or map of each tube was made, upon

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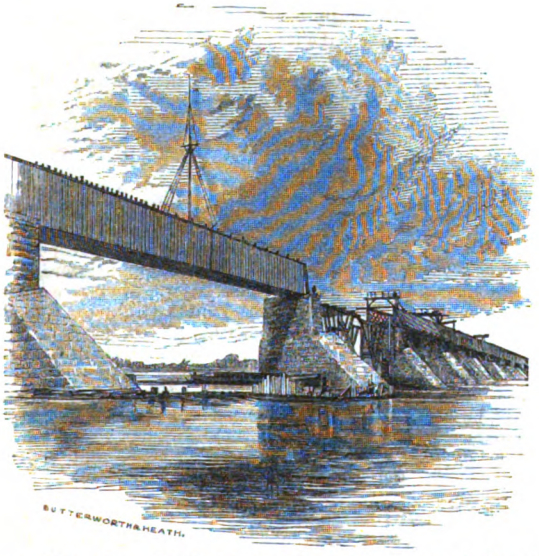
which was shown every plate, T bar, angle iron, keelson, and cover plate, in the tube, the position of each being stamped and marked upon it by a distinctive figure, letter, or character. As the work progressed at Birkenhead, every piece of iron as it was punched and finished for shipment was stamped with the identical mark corresponding with that on the plan; so that when being erected in Canada, although each tube was composed of 4926 pieces, or 9852 for a pair, the workmen being provided with a plan of the work, were enabled to lay down piece by piece with

Fig. 1.



unerring certainty till the tube was complete. To an uninitiated spectator this proceeding would appear as complicated and hopeless a task as the putting together of a Chinese puzzle; but to such perfection did they arrive at Birkenhead in making the plans, in preparing and punching the iron, and in shipping it, that when it arrived in Canada (where the iron for each tube was, as it arrived, sorted and stacked separately for use) the workman being provided with the plan would proceed with his work throughout, and never put a piece in the wrong place nor have to alter a single plate. It was not uninteresting to watch the gradual diminution of the pile of iron on the platform as the work progressed, and eventually to see the last piece taken to fill up some out-of-the-way hole or corner, and then to hear for certain that the tube was completed."

Fig. 2.



The notice of works in 1858 closes with a description of the temporary piers constructed to support the platform or scaffolding, absolutely required of the most rigid and unyielding form practicable to be erected, as had been impressed upon the attention of the contractors by the late Robert Stephenson. What we have just inserted, with that described on the commencement of the erection of the tubes in 1857, has rendered it and other modes sufficiently familiar.

The imagination can scarcely picture a more exciting or extraordinary scene than the works must have presented at the commencement of January 1859, when a great and successful effort was made to get up the central tube, and to make the opening of 330 feet which it was to span available for the navigation. A steam-engine working on the packed ice in front of No. 12 pier (one of those next the centre opening), not only transferring the iron from the sleighs to the trucks, but dragging the latter up an inclined plane formed from the packed ice to the top of the pier; while at the same time watchmen were employed night and day, and the engine was kept in full steam, with force-pumps and hose attached to throw water, to extinguish fire in case of such a necessity. While the plating of the bottom (centre tube) was advancing, forty gangs of "rimers" were at work night and day preparing the holes for the riveters, those gangs working at night being lighted by large fires in braziers. The men worked in heavy coats, thick gloves, fur caps, and handkerchiefs covering the greater part of their faces; even with all this they occasionally got frostbitten, as they only thought it too cold to work when there was any wind, and when the thermometer fell to 20° below zero (Fahr.), or 52° below freezing point; yet no man lost either a finger or a toe. When finishing this tube in March, in apprehension of the ice breaking up that had been so much relied on up to that time, more than four thousand rivets per day were got in and secured. This, the great centre tube, of 330 feet span (shown in Fig. 2), was completed within two months of a Canadian winter: it being the general opinion that, if the ice broke up before the tube was completed, it would have either fallen into the river, or been so damaged as to necessitate the taking it asunder. An idea of the accuracy of the tube-work prepared in England will be gathered from the following. Mr. Hodges says,—

"I have before noticed that the whole of the ironwork for the tubes was prepared at the Canada Works at Birkenhead (an establishment erected by Messrs. Peto, Brassey, and Betts expressly for the manufacture of the bridge work and rolling stock for their Canadian contracts). At these works every plate, &c., was finished ready for putting in place. I have likewise endeavoured to show with what care and accuracy this was done; but I trust I may be excused for again drawing attention to the extraordinary perfection attained in this ironwork. In the centre tube, consisting of 10,309 pieces, in which were punched nearly half a million of holes, not one piece required alteration, neither was there a hole punched wrong! The importance of this accuracy may be estimated by considering that had any portion been carelessly prepared, or even wrongly marked, a failure might have been the result, involving the delay of a year in the opening of the bridge, and a loss of many thousands of pounds. Therefore to Mr. George Harrison, the manager of the Birkenhead works, &c., and to his able assistants, Messrs. Alexander and Heap, is due as great credit for the successful completion of this work as to those engaged in its erection."

We must now notice a very ingenious contrivance, peculiarly suited to the urgency of the circumstances, and the shallowness of the water, with the soundness of river bed which allowed it to be adopted; we allude to the working or hoisting barge, called also, from its other application, a "turnwater," which appears to have done its work most efficiently.

"The current, as before stated, being very rapid, and cribs in the centre of the spans absolutely requisite for the temporary staging, some means had to be devised of putting them down rapidly, so that little risk might be run of their being carried away by rafts when probably half constructed, or perhaps when just finished, and only requiring weight to make them stable. To facilitate the work, a barge was fitted with a huge triangular-sided skeleton framing, about 30 feet wide, hinged to the deck by means of a strong transverse timber, and held up clear of the water by blocks and falls attached to a lofty derrick. The framing was so constructed that when the barge was moored in position it could be lowered in a few minutes, so that the four legs of the framework would rest upon the bed of the river, with only a few feet of the top out of water. As soon as it was fairly upon the ground, stones were laid upon a platform prepared to receive them, which, as the framework was only skeleton, offered very little obstruction to the current, and was easily kept in position. Planks were then laid on the sloping part against the stream, which were pushed down till they reached the ground. When the whole was covered with planking, the weight caused by the rush of water up the sloping face kept the mass perfectly firm, and formed an eddy in which cribwork could be framed and sunk with the greatest dispatch and facility. As soon as the crib was sunk and weighted, the turnwater (as the machine was called) was removed to another place, which operation, after the removal of the sloping planking and stones, was easily accomplished. This turnwater was used very successfully in some instances, but failed in others; nevertheless it was a valuable

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machine, and if it had been constructed at an earlier period of the work, might have simplified operations very materially."

Up to this period of progress with the centre tube, the eleventh pier had been left out for the purposes of navigation, and to pass the prodigious rafts that in the early summer always come down that great river. On the 5th of May no less than fifteen could be counted from the bridge, and a most exciting account is given of their passage, and of the miraculous preservation of the lives of the crew of one of the largest, that, coming broadside on, was broken up against the works, although carrying away almost everything temporary in its course: it was formed of baulks of oak, and manned by thirteen Indians, who were all "whirled down in the eddies under the barge and behind the turnwater," where they were distinctly seen struggling to free themselves from the tangled mass of timber; yet not one life was lost, as numerous boats, with a wise precaution, had been manned when the rafts first came in sight in Lake Prairie. To remedy the effects of this collision as quickly as possible, scows (a kind of flat-bottomed boat) 80 feet by 20 feet were procured; on one the staging required was erected, and the other, taken up-stream above it, was heavily loaded with stone, and scuttled as a moorring, and thus means were obtained for re-erecting the crib-work; and then, in the words of Mr. Hodges,

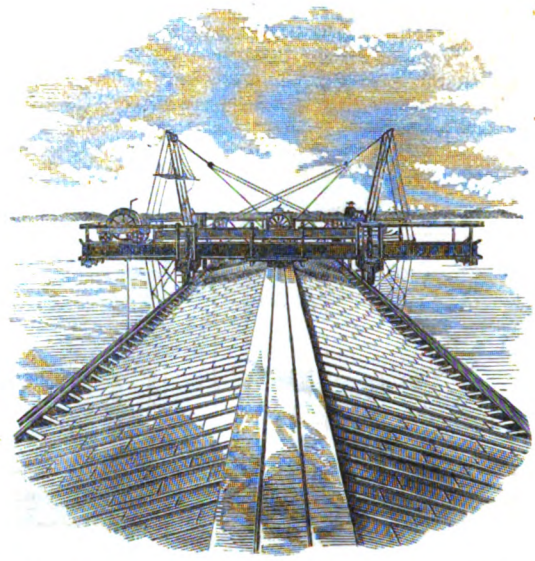
"Such a busy scene as this dam now presented is seldom witnessed. The works presented a small island of cribwork surrounded by barges laden with stone, timber, steam-engines, puddle-clay, traveller stagings, and pumping machinery, in the midst of which were crowds of men apparently in the greatest confusion. This, added to the shoutings of the workmen, the noise of the pile-engines, the "Yeo-heave-yeo" of the British boatmen unloading materials on one side, enlivened by a chorus of French Canadians chaunting their boat songs to the time of their work on the other, amidst a torrent of waters rushing past, with the surging and creaking of the barges as they tugged and tried to break adrift, formed at first sight such a bewildering scene of apparent disorder and confusion as can scarcely be described. A careful survey, however, must have satisfied the observer that, instead of confusion, everything was order. Observing the gang of men driving piles with a steam-engine at one place, he would not fail to notice that they were as indifferent to what was going on around them as if not a soul was there but themselves. So with a body of mechanics putting up pumping apparatus, or with the divers,—the men working the air-pumps as unconcernedly and with as much confidence as a philosopher would prosecute experiments in a closet. At another place, the dredging machine, worked by a steam-engine, would be seen scooping every bit of loose material from the puddle-chamber, while in the rear were men wheeling puddle into the clear space, each side of which was lined with men armed with rammers, puddling and working the clay into every hole and corner, so that there might be no leakage. The various works progressed so simultaneously and rapidly, that on the 2nd of August at 10·30 a.m. the engine was started, and pumping commenced. At 6·30 p.m. we were scrambling over the slippery boulders forming the bed of the river, while outside the dam the mighty waters rushed madly past at the rate of eight or nine miles per hour."

The removal of the earlier formed cribs, from their being filled with stone to a great depth, created a difficulty that it strikes us ought not to have arisen, for the unwatering or unballasting floating dams has been familiar to many for the last half-century; however, it is stated that "in the dams constructed during the last two years the stone filling extended to only some four or five feet below the water," and was of course more easily removed: and the next paragraph states, that when the stones were removed very little difficulty was experienced in removing the timber work, which was ripped up by steam cranes erected on barges, steadied by piles, in masses of twenty to thirty tons weight. It may be observed that such practice might have been well enough where there was a superabundance of timber. Nature herself appears to have performed the last act of this necessary clearing, for time not having admitted of the removal of the staging from No. 14 opening, on which the tube had been erected, on Dec. 17, 1859, about an hour before the time fixed for the first train to go through the bridge, a fearful crash was heard,—and the staging was seen drifting down the river with the ice, and, leaving the river thus perfectly clear, was considered as adding to the *éclat* of the day's proceedings.

The roofing of the bridge was of wood covered with tin, which was so laid as to allow the snow and water to run off from it.

"Upon the top of the ridge was a footway for workmen, 2 feet broad. Immediately over the sides of the tubes, rails were laid upon longitudinals of oak, bracketed up to allow for the passage of water under them. The rails were designed to carry a traveller bestriding the tube, to be used for painting, &c., and called the painting traveller. This traveller was made of iron, but as light as possible. It was so constructed that it could be moved to any part of the bridge, and from it any part of the outside of the tubes could be inspected or painted. Two travellers were made, one for each side of the bridge. From the great facility they afford, the whole of the outside of the tubes can be painted in five weeks."

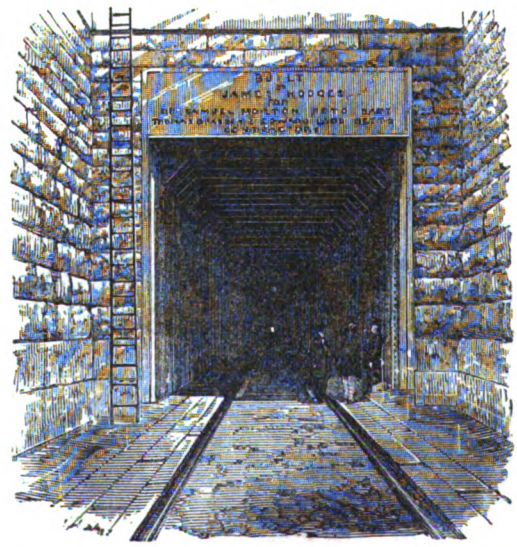
Fig. 3.



Considerable ingenuity is evinced in the arrangement by which the traveller is for the moment widened to pass the piers, by means of the purchase seen at top. Fig. 3 shows the traveller, with the roof and central footway.

The rails for the permanent track through the tube are of the ∩ pattern, 63 lb. to the yard, laid upon longitudinal timbers 14 inches by 12 inches, framed into one continuous beam, well bolted at the joints, and connected by transverse pieces of oak 14 feet apart.

Fig. 4.

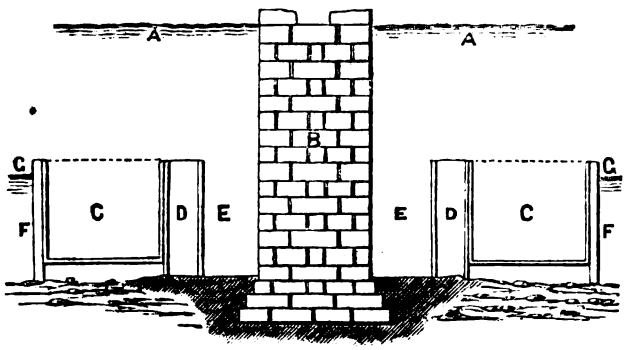


"Over the piers upon which the tubes are stationary, or where there are no expansion rollers, the longitudinal timbers are well bolted and keyed to the tubes, so that no creeping can possibly take place. At all other places the longitudinals are notched upon the keelson bars, and in the bolting of them down a space is allowed for expansion corresponding with the distance for the fixed piers. This continuous beam of timber being, therefore, held in place and keyed to the tubes at all the points where no expansion takes place, is not affected by the movement of the tubes from the variation of temperature. The tubes are lighted from the sides, in which holes are cut at every 60 feet. The interior is so light, that on a clear day every rivet-head inside of the tube is distinctly visible. A footway, 4 feet wide, is laid on one side of the iron track."

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In our first notice of this subject we observed, that probably a desire for brevity compelled the omission of details which would have been found useful if inserted. We give a section at the end of a pier of one of the floated or crib coffers, made out from the plan given and the heights and other data furnished in the work before us. A glance at the great breadth of the cross-section will show that in all probability, and taking into consideration the unwieldiness of the length, too much reliance was placed on the power to float such huge ready-made quadrilateral coffers into position; and even if that could have been effected, which it often was not, the retaining them in such a current and with moorings not the most reliable, until fixed, became an impossibility. The reader will also have seen the various expedients sought to be adopted, particularly those to unwater the site for an abutment. From the great length the abutments were to run out from the land, it was impracticable to hold such extended

Fig. 5.



Cross Section of Coffer Dam, showing the End of a Pier.

A. Maximum height of winter floods.
B. Pier in progress.
C. Floated crib coffer.
D. Puddling.
E. Space for working.
F. Main piles.
G. Summer level of river.

crib-coffers as were desired in position, broadside on and floating, even with the moderate depth of water and comparatively slack current next the shore. Mr. Hodges was therefore, as he says, obliged only to place the two end *scows* (crib-coffers, we take it to mean, although scows or large flat-bottomed boats were used for the same purpose), which were scuttled, and the guide and securing piles bolted to them, as in the other cases mentioned. At the up-stream side, instead of the vain endeavour to get in a long floating coffer, with puddle-chamber, &c., temporary crib piers (see Fig. 5, *ante* page 312) were erected at every 25 feet, and loaded. On the outer side of these, beams ran connecting them; sloping planking was then laid from end to end, as we have shown, the lower end resting on the bed of the river, by which means quiet water was at once obtained; behind this Mr. Hodges found sloping planking to be sufficient (which we have called "stockade piling") with a little fine gravel thrown on the joints and by the pressure of the water forced into them and held there; thus obviating the necessity for the formation of puddle-chambers on the up-stream face of the abutments. The scows or ends of the dams on the down-stream side, where still water was obviously obtained, were (as shown in Fig. 3, page 311), evidently connected by floated crib-coffers and puddle-chambers, which thus were extended round three sides. From this practical exemplification, and the many cases in which the floated crib-coffers of such great size could not be used in so rapid a stream, when formed into a complete quadrilateral, we are inclined to conclude, that what was here adopted as a *dernier ressort* (the placing of only the scows or cribs to be moored up and down stream) should be the universal practice in all large works and rapid streams, however shallow. We cannot believe but that an earlier adoption of such an arrangement would have obviated much delay, expense, and disappointment.

Taking a view of the whole case—and such requirements may and must arise in new countries—we are old-fashioned enough to be of opinion, that had not this present iron age driven out the adamantine, when Telford built the Chirk Aqueduct, the Highland bridges, and other great works of stone, the suitability of the situation and the circumstances to that material would in all probability have received more attention.

As a record of so great a structure, and guarantee for its stability, although our notice is of unusual length, we are induced to give the mode of testing, verbatim from Mr. Hodges, and a table shewing the lengths of the tubes, their weight, and the time occupied in their erection.

"The mode of testing the tubes was very simple. A piece of steel wire, about as large as common wire, No. 16 gauge, and which by experiment was ascertained would bear a weight of 380 lb. without breaking, was strained along the side of each tube. One end was fastened to a bracket at one extremity, while the wire passing over a grooved wheel attached to the other end of the tube was kept in a state of tension by means of a weight of over 300 lb., and which, although sufficient to keep

Statement showing Lengths of Tubes, their Weights, and the number of Days occupied in their Erection.

Number of Spans.	Days occupied in erection	Length of tubes between bearings.	Weight of One Tube.	Weight of one pair of Tubes, and Centre Tube.	Weight of Brackets, Roller Plates, Rollers, &c.	Weight of Roof, Permanent Way, Footpath, &c.	Total Weight.
		Feet inches.	Tons cwt. qr. lb.	Tons cwt. qr. lb.	Tons cwt. qr. lb.	Tons cwt. qr. lb.	Tons cwt. qr. lb.
1	69	242 0	296 14 0 7	588 12 0 11	33 12 3 14	57 16 2 16	680 1 2 13
2	54	244 0	291 18 0 4				
3	75	241 3	301 1 0 7	587 3 3 12	33 12 3 14	57 12 0 16	678 8 3 14
4	52	241 5	286 2 3 5				
5	58	243 11	301 11 3 12	593 9 3 10	33 12 3 14	58 3 1 16	685 6 0 12
6	50	243 4	291 17 3 26				
7	64	242 11	289 13 2 6	590 2 3 3	33 12 3 14	58 1 0 16	681 16 3 5
8	70	243 2	300 9 0 25				
9	39	243 6	297 5 2 19	608 17 1 24	33 12 3 14	58 7 3 16	700 18 0 26
10	46	245 10	311 11 3 5				
11	46	245 3	311 7 0 12	613 5 3 24	35 19 3 5	59 3 2 16	708 9 1 17
12	45	247 3	301 18 3 12				
Centre Tube.	47	330 0	686 6 0 11	686 6 0 11	28 15 3 14	56 10 0 2	771 11 3 27
14	44	247 5	303 4 2 12	613 1 0 18	35 19 3 5	59 5 3 16	708 6 3 11
15	50	245 11	309 16 2 6				
16	48	245 6	300 2 3 26	609 13 3 10	33 12 3 14	58 10 0 16	701 16 3 12
17	45	245 1	309 10 3 12				
18	44	244 7	302 3 3 26	591 3 2 3	33 12 3 14	57 18 3 16	682 15 1 5
19	51	240 8	288 19 2 5				
20	46	243 5	290 5 2 15	594 9 3 9	33 12 3 14	58 1 0 16	686 6 3 11
21	71	243 0	304 4 0 22				
22	78	242 4	294 1 2 22	584 12 1 23	33 12 3 14	57 16 2 16	676 1 3 25
23	63	242 5	290 10 3 1				
24	66	242 0	292 11 3 19	590 3 2 7	33 12 3 14	57 12 0 16	681 8 2 9
25	84	242 0	297 11 2 16				
				7851 2 1 25	437 4 0 24	754 19 2 26	9043 6 1 19

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the 250 feet of wire nearly straight, and almost as tight as a fiddle-string, was not sufficient to break it. This weight always acted freely upon the wire, irrespective of any movement or deflection caused by the passing of a train, the versed sine of the natural curve being always the same. The wire in this state was used as a datum from which the deflection caused by the passing of a train was measured. Wires such as those described were strained throughout the whole of the tubes; and at intervals of 60 feet, strips of cardboard were so placed and attached to the tube that the wire just played upon without actually touching them. These arrangements being completed, and a mark made upon the cardboard to correspond with the position of the wire when the tubes were not loaded, similar marks were made when the load was in the different positions given to it. The actual deflection was thus very readily ascertained. In the spring of 1858, Mr. Stockman, who had been employed under Mr. George Robert Stephenson in making the working drawings for the whole of the tubes and girders used in the construction of nearly 1000 miles of the Grand Trunk Railway, was sent to Canada by Mr. Robert Stephenson, for the purpose of inspecting the tubes, and ascertaining whether any defects either in design or workmanship could be discovered in any of the works; so that in making designs for future works, advantage might be taken of the experience that was thus obtained. During his visit the tubes of the Victoria Bridge which were completed were fully tested. Mr. Stockman reported the workmanship and material of the tubes to be unexceptionable. Again, in December 1859, just before the Victoria Bridge was opened, Mr. Bruce, an engineer of great experience, and who had for many years enjoyed Mr. Robert Stephenson's confidence, visited Canada, accompanied by Mr. Stockman, and witnessed the final testing of the whole of the tubes."

The book is elaborately got up, and contains a most minute account of the construction of the great bridge in every detail; but we deplore the erroneous conclusions arrived at by the author in that portion of the historical matter relating to the design. We are at a loss to understand how the name of Mr. Alexander Ross is substituted for that of the late Mr. Robert Stephenson, who was the actual designer of the Victoria Bridge in its present form; and we think more should have been said of those gentlemen who were responsible to him when arranging all the elaborate and important details of the vast superstructure, not one particle of which, we know, ever emanated from other hands.

To Mr. Weale, we understand, the public and the profession are mainly indebted for the tact, taste, and energy which produced so splendid an addition to the practical library in an incredibly short space of time (we believe seven or eight weeks), by a combination of talent and capital upon the one object of a publication that for finish and beauty has rarely been exceeded.

Institution of Civil Engineers.—Premiums.—At the meeting of the Council held on the 23rd ult., premiums were awarded to the following gentlemen for papers read during the last session:—A Telford medal and Council premium of books to J. J. Berkley, Member; a Telford medal to R. B. Grantham, Member; a Watt medal, and the Manby premium, in books, to J. A. Longridge, Member; a Council premium of books each to Messrs. E. L. Williams, E. B. Webb, F. C. Stileman, J. R. Walker, Members, and D. K. Clark, Associate.

Lyndhurst, Hants. — During the past month the parish church of Lyndhurst, in the New Forest, has been re-opened, after the rebuilding of the nave and north aisle, which was begun rather more than a twelvemonth since. The former structure, built in the reign of George II, and exhibiting all the inarchitectural features of that period, contained sittings for only 450 persons, while the present church holds about 680. It has been built in the Early Decorated style, from the designs of Mr. White, of Wimpole-street, London. The walls are of brick, arranged in coloured bands and patterns. The plan of the whole consists of chancel aisles, quasi-transepts flush with the aisles, and a lofty nave. Besides the chancel arch there is a richly carved central arch, supported externally by pinnacled buttresses. Foundations are laid for a north-west tower and spire. The floor is principally composed of wood brick, laid flat, and herring-bone fashion, thus forming a dry and noiseless floor. The bricks used in the walling are grey, brown, three shades of red, two shades of buff, and white. The pillars are also of brick, banded and clustered with marble shafts. The roof is of unwrought deal, with diagonal boarding between the rafters. The seats are wide, and without doors. The whole cost has rather exceeded £3000.

New Bridge, Malahide.—The new bridge now erecting by the Dublin and Drogheda Railway Company at Malahide, near Dublin, is stated to be a structure comprising strength with gracefulness of proportion. There is a very strong current at that point, and engineering skill has been seriously taxed both in preparing for the new bridge and providing a temporary one of timber over it, that the traffic might proceed uninterruptedly. The piers are of stonework, and the superstructure of iron. Mr. Harty is the engineer.

Staircases superseded.—The hotel about to be constructed by Pereire, opposite the new Opera House, Paris, it is said, will be the largest in existence. The staircase will be entirely dispensed with, and the inmates, goods, and luggage, are to be raised and lowered by machinery.

Birkenhead.—The gigantic dock at Birkenhead is fast approaching completion. The total water space of the Great Float is 110 acres, and the lineal space round it is upwards of four miles. The depth of water will be about 9 feet below the old dock sill at Liverpool.

The Royal Academy.—The Lectures on Architecture at the Royal Academy will this session be delivered by Mr. Sidney Smirke, R.A., on the evenings of January 24th, 31st, and February 7th.

Royal Institute of British Architects.—The opening meeting of the Institute will take place on Monday the 5th instant, when Mr. Sydney Smirke, R.A., will read a paper entitled "Recollections of Sicily."

The Architectural Association.—The *conversazione* and opening meeting were held on the 26th ult., in the galleries, Conduit-street, when the President, Mr. T. Roger Smith, delivered the inaugural address. The evenings of November 9th and 23rd will be devoted to "Consideration on the subject of Architectural Examinations, and report thereon."

Railway Rails.—Messrs. Barningham, of the Darlington Iron Works, are rolling a large quantity of rails of unusual dimensions. They are 27 feet in length, and weigh 82 lb. to the yard.

New Church, Twinstead, Essex.—The new church here, dedicated to St. John the Evangelist, was consecrated on the 20th of October. It consists of chancel and nave, with south porch and vestry, and organ chamber on the north side of the chancel, the western bell-turret forming a conspicuous feature in the building. The material employed is for the most part red brick, banded in the exterior with black and amber coloured bricks. In the interior a system of arcading in coloured brickwork extends to the whole wall surface. On the north and south sides of the nave the arches occur under a species of trellis of coloured work, and at the west end the main arches support a second arcading of smaller compartments. In the chancel the arcading takes the form of a dadoing, supporting a richer arrangement of band-work, which terminates at the east end in geometrical forms. A triple arch separates the chancel from the nave, with a low stone screen beneath. The chancel windows have been filled with stained glass by Hardman. The font is slightly inlaid with coloured marbles, and attached to it is an iron canopy, from which the oaken cover and balance weight are suspended. Open benches are ranged on each side of the nave, and benches of a more elaborate character occupy the place of stalls in the chancel. The pulpit, which is of oak, contains the emblems of the evangelists, and the sacred monogram. The architect is Mr. A. Woodyer.

The Pneumatic Despatch Company.—The engineers to the company state that by the use of the fan, which is elaborate, but economical, they can obtain a speed of thirty or forty miles at a very trifling cost. The first pipe is to be laid from St. Martin's-le-grand to Bloomsbury, for postal purposes.

Competition.—Plans are invited for covering in the area of the Royal Exchange, London. Premiums, £50, £30, and £20. The designs must be prepared with regard to ventilation and non-interference with the light of the windows looking into the area. Information may be had of Mr. G. Smith, Frederick's-place, Old Jewry. Plans to be sent in by December 1.

Competition.—Designs are required for a town hall, with offices and police-station, and detached separate boys' and girls' schools, at Grimsby. Plan of the site and particulars may be had from Mr. J. Maughan, Grimsby. Designs to be sent to Mr. G. Babb, Great Grimsby, till December 29.

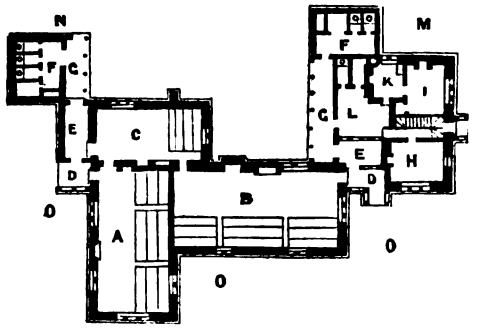
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HENHAM AND WANGFORD SCHOOLS, SUFFOLK.

(With an Engraving.)

THESE schools, of which we give a perspective view, occupy an elevated site on the eastern side of the road leading from Blythborough to Wangford, Suffolk; the park at Henham being on the western side. They have just been completed, and consist of a boys' and girls' school of nearly equal dimensions; a smaller school for infants, and a teachers' house with an entrance porch; hat and cloak room to each school, and the requisite offices. In style they are an adaptation of the French Gothic. The material employed for the walling is round stone, banded and quoined with red and white brick. The roofs are of tile, with bandings of white ornamental tile. The ridge is crested in red tile, and a timber spirelet or belfry turret rises from the main line of the same. The upper portion or gabled coverings of the windows are in timber, and terminate in ornamental finials in lead and iron, as do all the other apices of the roof, both gabled and hipped. The porches and the hat and cloak rooms are timber framed, and there is a timber penthouse over the entrance to the residence. The roofs internally are open timbered, and ventilation is obtained by perforations in the roof and by the circular eyelets shown in the timbered gable-heads of the windows. All the timber-work, both externally and internally, is covered or coated with pine varnish, slightly darkened with Stockholm tar. The back ground is appropriated to play-grounds; the front, to the approaches and plantation. The site was the gift of the Earl of Stradbroke; the Countess of Stradbroke was also a liberal donor: a government grant and local subscriptions making up the amount required.

The schools were erected from the designs and under the superintendence of Mr. E. L. Blackburne, architect, of Grenville-street, London. Mr. Mortimer, of Wenhaston, Suffolk, was the contractor for the works, at somewhat under £1000; Mr. Croft, of Wangford, performing for him the carpenter's portion of the same; Mr. Keable, of Henham, acting as clerk of the works.



References to Ground Plan.

A. Girls' schools.
B. Boys' school.
C. Infant school, used also as a class-room.
D, D. Porches.
E, E. Hat and cloak rooms.
F, F. Closets.
G, G. Covered ways to ditto.
H. Parlour—teacher's house.
I. Living room.
K. Scullery.
L. Yard.
M. Boys' playground.
N. Girls' and infants' ditto.
O, O, O. Approaches and plantation.

THE EXHIBITION OF BUILDING MATERIALS, MANUFACTURES, &c., CONDUIT STREET.

WITH the close of the architectural picture season at these galleries recommences that of the more practical character, the exhibition of building materials, models, patents, &c., the opening of which we just announced in our last number, and upon which we shall now offer a few comments. It may be premised that this is an institution which has been associated comparatively recently with its elder sister, but one calculated to be of essential service in furthering the interests of the able and ingenious tradesman, nor will prove less instructive to the man of science and education generally. There is much yet to be done before these objects are placed on a worthy footing. First, the manufacturer must see the advantage of this medium of making known his articles; and next, the seeker after such articles must know that they are here deposited, not in single samples but in a competitive range, so that while one party is stimulated to his utmost in perfecting the quality and attractiveness of his goods, the other will find it worth his while to investigate for himself into their intrinsic recommendations, and thereby have that opportunity of bonâ fide comparison which in the ordinary course of business is wholly unattainable. To insure this is manifestly advantageous to the skilful practical adventurer in art, and we should be glad to see more of that class among the exhibitors this year. As it is, those who have inspected the displays on the two previous years will have become acquainted with the names and productions of the majority of those that are now submitted to their notice. Not that we complain of this; on the contrary, it betokens on behalf of such parties a satisfaction as regards the past, but this should surely incite others to follow their example; had this occurred there would be no occasion to regret (as now) that the three galleries occupied are by no means overfilled, while the first room which the visitor enters is, unfortunately, entirely empty.

It is with cordial good wishes for the improving success of this undertaking that we venture on these remarks, and have yet one or two to add. There ought unquestionably to be a catalogue, as descriptive and detailed as possible, and if illustrated, so much the more acceptable. Some exhibitors have diagrams and woodcuts for their handbills already prepared, which would be quite available, and which they would doubtless be glad to introduce among others in a form which would thus be of sufficient value to preserve for reference, independent of its primary object; then again, in every case, information as to prices, net and wholesale, arrangements and cost of carriage (if any), the names of duly authorised agents, and references as to works actually executed, should be liberally afforded. But how are these requirements met in the present state of things? Will it be believed that there is no catalogue at all, in any shape whatever? Failing this, one has to resort to other expedients for gaining information, the most natural being to scrutinise for labels on the objects themselves; this is in most cases so far successful. But this is not always so, and then questions must remain unsolved, unless the inquirer bethink himself of applying to the curator in attendance, to whose courtesy in such a dilemma we have been more than once indebted, and who, it is but just to say, is ever ready to give the fullest information in his power. But, as it sometimes happens that he has not been primed for the occasion, there is no alternative but to put up with the disappointment. This want of a catalogue—it was so also last year—appears an inexplicable error on the part of the management; the want of "particularising," a scarcely less short-sighted policy on the part of the exhibitors. The idea of the latter may be to lead parties to apply at headquarters, and thereby pave the way to direct business transactions; but it seems equally probable that the reverse may take place, and that people who, if they could be made acquainted with all they naturally wish to ascertain, would have opportunities as well as the disposition to patronise meritorious works, now retire, to pursue the old beaten track; and thus the primary object of the exhibition sustains a check, instead of receiving a stimulus. It is not yet too late to remedy these matters; and since we have reason to know that we are not singular in our opinions, we shall hope ere long to witness a speedy improvement.

It has been stated that several of the largest exhibitors have retained their show-space from season to season, exchanging or varying the articles exhibited as seems desirable. Among such parties may be recognised Messrs. Minton, Maw, Desachy, Doulton, Jennings, Botten, Fayle and Co., Hart and Son, Johnston Brothers, Ransome, Cox and Co., &c. Having on previous occasions dwelt at length on the various productions of these well-known firms, it will be unnecessary to say more here than that in the present collection each is worthily represented. We have before alluded to Messrs. Williams, Cooper and Co.'s paper-hangings, as being unusually good of their kind; we can now refer approvingly to those also of Messrs. Harland and Fisher, of Southampton-street, Strand, who exhibit some meritorious Gothic designs, albeit some look rather too much like tile-paving arrangements. Messrs. Arrowsmith's parquetry is now well known, and the mode of its construction can be readily appreciated from the specimens contributed for the purpose in the rooms. It will be seen that it is solid, and not a mere veneer. Messrs. Jackson & Sons, and White & Parlby, again rival each other in the purity and elegance of their composition enrichments for internal decoration. The show of the latter firm is of the

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most elaborate kind, and displays perfection and refinement of finish in a surprising degree. A fine specimen of wall diaper in relieved ornament is among their best specimens.

Fox's "Patent silvered glass" has received some new applications, and its lustrous effects are conspicuous in various ways. Hobbs's locks, and Tann's new "guarded" lock are always deserving of notice, as is Hart's door furniture generally. We miss this year Skidmore's metal work; specimens by Hardman, Potter, Keith, and others, are also wanting.

Messrs. Devaux exhibit a great variety of applications of zinc, as an ornamental as well as economical roofing material. It has been already described and illustrated in our pages. In Smith's "Ornamental woods" for internal decoration, the effect is apparently produced chiefly by burning: it is stated to be a durable and inexpensive process. Some imitations of marbles evidence the highest artistic ability. A series of large panels, by some exhibitor whose name we could not discover, are perfectly marvellous: they comprise imitations of Languedoc, Sienna, Rouge royal, Rouge vere, Pavonozetta, and Irish. Near them are also some capital imitations of the wood of the yew-tree, satinwood, cotton-tree, &c.

Among the novelties will be observed two hydraulic lifting jacks (patent), by Messrs. Daniel Adamson and Co., of Hyde, near Manchester, which appear to be no less effective than simple in construction. Pierce's stoves still assert their pre-eminence, and their qualities have now been tested by the public for many years. Edwards' "Patent chimney bar, and ventilating hearth-plate," is shown by diagrams and a full-sized model. In using the chimney bar (the contrivance of which is very simple) the flue is at once formed of the proper size. The effect of the contracted opening is greatly to improve the chimney draft, as the large open space usually left is unnecessary and objectionable. There is a register door which is opened or closed by means of a handle in the front. The hearth-plate is of cast-iron, and has a sliding ventilator. It communicates with the external air either between the flooring joists or by means of air bricks in the external walls. Boyd's fire-lump grates have the recommendations of being based on correct principles and being cheap. The back and two cheeks are entirely of this material, which is stamped into a somewhat architectural form, well suited to its purpose. In some of Boyd's fireplaces colour, as well as good architectural effect are attained by the introduction of pattern tiles in the sides and hearth. These tiles are prepared expressly for the purpose by Mr. Godwin, of Lugwardine, near Hereford, who has brought the manufacture generally to a high state of perfection. Boyd's "flue plates" are made in various sizes, and are intended to be built in walls, so as to form a hollow ventilating partition between two smoke flues.

In Elkin's "Patented improvements in window frames and sashes," shown in a model, the improvement consists in that portion of the frame called the pulley-style being made loose instead of fixed; it is kept in its place by an elastic arrangement at each end, and the face of the pulley-style is thus made to press equally against the edge of the sash. The removal of the sash is effected by pressing it sideways against the elastic pulley-style, which yields sufficiently to allow the sash to be disengaged from the beads of the opposite pulley-style. The free side is then drawn inwards, and the other side of the sash liberated from the elastic-style; the line is then simply unhooked, and the sash is disengaged. The pulley-styles may then be lifted out of the frame to repair weights or lines.

Several other models will be found to repay examination, but as they do not readily admit of description, we shall leave them, with the collection itself, for personal inspection.

ST. SEPULCHRE'S CHURCH, NORTHAMPTON.

THE most worthy motives for the restoration and enlargement of a church are those which appeal to our piety and charity; but a special interest of another kind will sometimes attach to a particular church, such as belongs to that of St. Sepulchre, Northampton, the repair and enlargement of which has just been commenced.

The great peculiarity of this church consists in its being one of the four round churches, and four only, remaining in England. Two of these churches were erected by the Templars and Hospitallers respectively; two religious orders, associated under the most solemn vows for the protection of pilgrims to Jerusalem. These were the Temple, in London, so called because it belonged to the Templars; and Little Maplestead, in Essex, which was attached to a Commandery of the Hospitallers. The other two churches can, however, boast of a higher antiquity, and are both dedicated to St. Sepulchre; the one being at Cambridge, and the other the building now under consideration. Of these, the church in Cambridge has, perhaps, the priority, having been consecrated in 1101; but that in Northampton followed immediately after, being assigned, with great probability, to Simon de St. Liz, Earl of Northampton, who died in 1115.

The condition in which he left the church of St. Sepulchre's may be inferred with tolerable certainty from several indications still remaining. It seems indubitable that it consisted of the present round, together with a chancel, terminating in an eastern apse. The principal entrance was most likely through a highly enriched doorway at the west end of the round, which has since given place to the present lofty tower and spire. Instead of a tower or other steeple to the original church, the round was crowned with a high clerestory or lantern, with a conical roof, also of high pitch; and, as there was a triforium over the aisles of the round, which has now disappeared, the whole elevation would not be deficient in height. The chancel, probably, had no aisles, being in that respect like Little Maplestead, and which it very possibly resembled too in its apsidal termination.

In the interior, the central circle of eight pillars and arches was surrounded with an aisle with a groined roof, over which was a triforium, opening into the church by a series of arches, probably little inferior in height to those below. Resting on them, and rising to some considerable height above them, was the clerestory or lantern, doubtless of eight lights, with appropriate decorations. A richly moulded arch would lead to the chancel, the details of which can now be supplied only from analogy. But though there is no reason to doubt that it was, both internally and externally, a structure of considerable elegance, it did not satisfy more than two or three generations in the state in which Simon de St. Liz left it, for, apparently about 1180, during the time of the gradual introduction of the pointed arch, but while the old Norman details were generally retained (thus forming a transition era) the northern wall of the chancel was cut through, to form an arcade, for the addition of a northern aisle. The work does not seem to have been judiciously or even carefully conducted, for the changes about this time originated in a series of failures in the fabric, which led first to the necessary erection of certain unsightly buttresses, and ultimately, perhaps, to the failure of the round and the sacrifice of the old triforium and clerestory. The twelfth century, however, probably closed upon a church scarcely differing from that which St. Liz had finished before 1115, excepting that a northern aisle had been added to the chancel.

There, so far as at present appears, the church remained for upwards of a century, for it is not till early in the 14th century that there are any indications of a southern chancel aisle. It was also before the close of the same century that the present tower and spire were erected. This was not without a purpose, for the round had probably suffered so much by former changes as to require great repairs. The aisle vaults, the triforium, were in all likelihood, sacrificed at this time, the clerestory being rebuilt on a more meagre scale, though certainly not so miserably as at present. A tower and spire were therefore required to give character to the church, and the one which has been raised is in every respect worthy of the county more especially noted for its beautiful steeples.

In dealing with such a building for the purposes of enlargement, it was by no means an easy task how best to accomplish it, without too much disturbing the various peculiarities which its ancient architecture presents. To interfere with the "round" was of course out of the question, consequently all that could be attempted must be eastward; and the additions, of which the first stone was laid with due ceremony on the 11th of September, comprise an extension of the parallelogram portion with its two aisles to serve as the church proper, and a still farther extension eastward of the centre portion serves as the new chancel, which will be terminated by an apse. These alterations are in accordance with drawings prepared by Mr. G. G. Scott, who has already restored the Norman church of St. Peter's, in the same town. The funds at present in hand not being sufficient to warrant the undertaking of the whole at once, the contract has been divided into three sections; the first comprising the structure of the proposed enlargement (exclusive of vestry and new north aisle)

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with roof thereto, including a temporary roof to join the old and new work. The second portion consists of the new north aisle and vestry porch, and the substitution of new roof in place of the old one eastward of the round portion of the edifice; and the third comprises seating and fitting up of the church throughout.

The tender of Mr. W. M. Cooper, of Derby, being the lowest, was accepted, and ran as follows:—For section 1, £1937; for section 2, £1633; and for section 3, £1650 (subject to a reduction of £280 in case of pine being used for the sittings); making a total of £5220, or, with the reduction, £4940; and a contract was entered into for the execution of the first named section of the works, which were practically commenced in June. Local materials are being used as far as possible, the walling stone being procured from the neighbouring quarries at Duston. Coursed bands are to be occasionally introduced, and marble, to some extent, internally.

RESTORATION OF KILKHAMPTON CHURCH, CORNWALL.

This church, situate in a remote district in the upper corner of the county of Cornwall, on the high moorland road from Clovelly to Bude Haven, has obtained a degree of notoriety as having been the building which gave rise to Hervey's well-known 'Meditations among the Tombs.' The edifice, which was lately in a very dilapidated state, has now acquired a fresh interest from the extensive and substantial alterations which have taken place, a change mainly due to the liberality of the Rev. Lord John Thynne, sub-dean of Westminster, and whose son, the Rev. A. C. Thynne, is rector of the parish;—the parishioners assisting in the restoration of the nave. The exterior has been substantially restored, due regard being paid to the ancient south doorway, a fine example of Norman work. Considerable portions of the walls were rebuilt; the east end of the chancel and chapels entirely so, new windows being also placed therein; the roofs throughout have been entirely stripped, repaired, and covered with slate, the plastering when removed from the underside having brought to light a carved and bossed cradle-roof of oak. The whole of the pillars have been cleansed from accumulations of whitewash, &c., and the chancel entirely remodelled. In this part a cumbrous Classic altar-piece no longer obscures the east end, and the chancel and chapels are screened off by traceried and carved screens, that at the west end of the chancel being a low screen panelled. Entirely new oak seats have been placed in the chancel and chapels, the chancel and sacrarium being floored with Minton's tiles. The elaborately carved old seats of the nave have been carefully preserved and refixed on a new floor. The pulpit is new, richly carved in oak on a granite base; it is placed on the north side of the nave in front of the low chancel screen. A white metal lectern with brass ornaments has also been provided. The east windows of the chancel and chapels, and the side window of the latter, together with the west end window of the tower, have been filled with stained glass, from the designs of Messrs. Clayton and Bell: they are partly heraldic in character, and partly emblematic. The centre east window, of five lights, represents the Crucifixion and Sufferings of our Lord. The east window in the south chapel sets forth the Resurrection, while the two four-light windows on the south side of this chapel (which is the mortuary chapel of the Granvilles) represent the genealogical descent of that family from their Norman extraction to the extinction of the male line, and these have been contributed by various distinguished individuals "as a tribute to the memory of that ancient and loyal house from which they are respectively descended." In the corresponding chapel, Lady Carteret, widow of John, last Lord Carteret, has caused a window of like character to be placed, in memory of the descendants of John Granville, Earl of Bath, by whom the Kilkhampton property has been transmitted to its present possessor. Another window (four-light) contains figures of the four major prophets, and a three-light window commemorates the Birth, Presentation, and Baptism of our Lord. The window at the west end, seen through the lofty arch of the tower, is enriched with stained-glass by the rector and his wife, in memory of his brother, Captain W. F. Thynne, of the Rifle Brigade, who fell at Lucknow. The stone-work and roofs were restored and repaired by Messrs. Firks and Bone, of Liskeard; the fittings of the chancel, screens, and pulpit, by Messrs. Clarke, carvers, of Mells, near Frome, Somersetshire.

MAW'S MOSAIC AND ENCAUSTIC TILE WORKS, BENTHALL, SHROPSHIRE.

At the recent meeting of the British Archæological Association at Shrewsbury, the members visited the works of Messrs. Maw and Co. at Benthall, when Mr. George Maw explained the process of the manufacture. He said that it consists of two distinct branches, which are essentially different in nearly the whole of their processes. First, the making of encaustic tiles, or those inlaid with a pattern of two or more colours, which is the reproduction of an art limited in the mediæval times to church decoration, but now having a much more extended application. Secondly, the manufacture of plain tiles and tesseræ, of an uniform colour, used in the construction of geometrical mosaic pavements, similar in character to those found in the mediæval buildings of Italy; also moresque mosaics and tesselated mosaics, similar to those occurring in Pompeii and almost all Roman remains in this country and the Continent. The materials employed in both processes are nearly identical, and consist for the most part of the clays and marls of the Shropshire coal measures. These, without any colouring matter, together with clays from the south of England, form the red, buff, and fawn coloured tiles; and, in connection with different proportions of oxides of iron and manganese, the black, chocolate, and grey tiles. The white and all the richer-coloured tiles and tesseræ are formed of a species of porcelain, or parian, the white left uncoloured, and the blues and greens coloured with oxides of chrome and cobalt. The preparation of what is technically called the body of the tile, which is the first process in the order of manufacture, consists in mixing the constituent clays and other materials with water, and commingling and purifying by passing them in a semi-liquid state through a sieve made of the finest lawn, containing between 10,000 and 15,000 perforations to the square inch. All the coarse particles are by this means removed, and the texture of the clay rendered perfectly fine and even, as well as adding greatly to the brilliancy of the colour. The semi-liquid purified clay is then dried in what is termed the slip kilns,—if for the manufacture of encaustic or inlaid tiles in a plastic state, or for plain or self-coloured tiles, perfectly dry and hard. It is at this point that the two processes diverge, and are essentially different. There is also some slight difference in the proportions of the materials used in their composition, but this need not be more than noticed. The encaustic tiles are made of plastic clay, the pattern impressed from plaster of Paris moulds, and the indented surface filled in with different clays in a semi-liquid state. The tile is then allowed to gradually dry to the consistency of wax, and the inlain patterns developed by scraping off the superfluous clay. For the manufacture of the plain tiles, of one colour throughout, the material, which has been dried quite hard in the slip kiln, passes through a machine which grinds it to a fine powder, ready for moulding, which is performed in steel dies, under very powerful screw presses, some of which work at a power of thirty tons. Both kinds of tiles after having been formed, are placed for ten days or a fortnight in a drying stove, an apartment heated by flues up to 80 or 90 degrees, and when the whole of the moisture is driven out they are ready for burning. This is performed in large kilns, the tiles being stacked in fire-clay boxes, termed saggars; the actual burning occupies four days and nights, during which time they are gradually brought up to a white heat by the consumption of from 18 to 20 tons of coals, and during another four days and nights are as gradually cooled, occupying the kiln in a hot state eight days and nights. Great care is necessary in this part of the process to give the correct amount of heat throughout the kiln, as if the firing is not carried sufficiently far, the tiles are soft and irregular in colour, which necessitates a repetition of the process; and if carried beyond a certain point, they gradually decrease in size. They are judged of by certain tiles, (technically termed "proofs,") from time to time drawn out of the kiln during firing. The whole contents of the kiln may be spoiled in a very few minutes. The great bulk of the tiles are employed in the unglazed or biscuit state, the manufacture of which is completed with the burning. They have merely to be drawn from the kiln, and as they somewhat vary in size and colour, depending on the precise extent to which the fire has been carried on, they have to be passed through a gauge which divides all the larger forms into four distinct sizes. The process of glazing or enamelling is performed by applying a thin coat of paste, made of vitrifiable materials, on the tiles that have been previously burned, which is converted into a glass by subjecting

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them to a low red heat in a small furnace termed the enamelling kiln. Glazed tiles are principally employed for Bath linings, and the sides and backs of fireplaces; also for pavements in combination with unglazed tiles, with which they form a very pleasing contrast.

THE LATE JOSEPH LOCKE, C.E., M.P.

It is with the greatest regret that we have to record another sudden and most serious loss to the engineering profession, in the death of Mr. Joseph Locke, which occurred at Moffat, on the 18th ult., in his 55th year. He was a native of Attercliffe, near Sheffield, where he was born in 1805, and received his education at the grammar school of the neighbouring town of Barnsley. His education being completed, Mr. Locke was placed under George Stephenson, at Newcastle, being bound for a period of five years. In 1826, when his apprenticeship was drawing to a close, the railway between Manchester and Liverpool was begun —the first great work under the modern railway system, and of which his master was the chief engineer. Under Mr. Stephenson, Mr. Locke was engaged on the line from its commencement to its opening, towards the close of 1830. His services during this period "were especially valuable with reference to the selection of motive power," ending as they did in the full perception by all concerned of the superior advantage of the locomotive engine. The pamphlet, published in 1830, in the joint names of Stephenson and Locke, on the disputed point, settled the question, although rope traction here and there continued to be used for a few years longer.

Mr. Locke's next great work was superintending the line from Birmingham to Warrington, now so important a part of the London and North-Western system. The line was commenced in 1832-3. Stephenson was again engineer-in-chief, but on Mr. Locke devolved the personal charge of the work from its commencement. Besides certain improvements in the rails and their fixing, one great merit in his construction of this line was its comparative cheapness, the cost not exceeding from £14,000 to £15,000 per mile. Besides the Lancaster and Preston, and other Lancashire lines, Mr. Locke undertook the engineering of the London and Southampton line, to which he devoted the major part of his time. The line was completed in 1840, since which date it has been extended by many branches. In the last-mentioned year he also undertook the construction of the Manchester and Sheffield line. Of Mr. Locke's subsequent railway works in this country, the most important was the construction of the system from the manufacturing districts of Lancashire to Edinburgh and Glasgow, the political and commercial capitals of Scotland. In this work he was united with Mr. Errington. Years before it was commenced Mr. Locke had sketched what he thought was the best course for the Caledonian line to take. Having to penetrate the rockiest part of the south of Scotland, the undertaking presented many difficulties, which it is admitted Mr. Locke overcame as satisfactorily as it was possible to do. On this line also, with its heavy works, he combined economy with excellence, the cost not averaging more than £16,000 a mile. There are heavy gradients on the line, but these have presented no particular difficulty to the locomotive in practical working. The Scottish Central, the Greenock, and other lines connected with and in continuation of the Caledonian, were all executed under the advice and superintendence of Messrs. Locke and Errington.

Mr. Locke has had a large share in the construction of the continental lines. Among the most noteworthy are the Paris and Rouen, the Rouen and Havre, Paris and Lyons, Caen and Cherbourg, several of the Spanish lines, the Dutch Rhenish, &c. In 1845 Mr. Locke received the decoration of the Legion of Honour from Louis Philippe: he was also a Fellow of the Royal Society, and M.P. for Honiton since 1847, having purchased the lordship of the manor of that place. He was but two years the junior of Robert Stephenson. He has survived Brunel exactly a year. It is remarkable that his death should follow so suddenly upon those of Stephenson and Brunel, to whose position it was allowed he was the heir, as the remaining chief of the engineering profession. The Civil Engineers had agreed in according priority to Locke, who succeeded Robert Stephenson as the President of the Institution, filling that office in 1858-9. This position was his due, as the chief representative of the Stephenson school.

MONUMENT TO THE LATE MAJOR HODSON, LICHFIELD CATHEDRAL.

(With an Engraving.)

The monument of which we gave an engraving in our last number is about to be erected in Lichfield Cathedral, to the memory of the late distinguished Major Hodson, of "Hodson's Horse," whose untimely death in the final assault upon Lucknow will be fresh in the memory of most of our readers. The work is to be executed by Mr. Earp, from the designs of Mr. George Edmund Street. The materials to be used are Caen stone, Mansfield stone, black limestone, alabaster, serpentine, and marble. The sculpture of figures and subjects is to be all executed in white alabaster. The central subject in the side represents the surrender of the King of Delhi to Major Hodson. The four figures at the angles are David, St. Paul, Arthur, and St. Alban—types of the Christian warrior in all times. The four quatrefoils (one at each end and two on the side) are to bear representations of four military virtues — Justice, Fortitude, Temperance, and Mercy. The cross and the coped top of the monument are to be entirely of serpentine.

The monument will stand under one of the arches on the south side of the choir, nearly opposite to the costly and elaborately sculptured monument to the memory of Archdeacon Hodson, the father of Major Hodson.

MR. SPURGEON'S NEW TABERNACLE.

The works at Mr. Spurgeon's new place of worship on the Surrey side of the river have progressed with great rapidity since the foundation-stone was laid. The building is now entirely roofed, and the interior is in a very forward state, the ground floor being laid, a portion of the walls lined with matchboarding, and the frame-work of the extensive galleries completed. Although the building of the towers which were introduced in the original design has been abandoned, the new edifice presents an imposing appearance. The walls of the chapel rest on dense concrete 3 ft. 9 in. in depth, the lower stratum being a stiff gravel, so that the foundations throughout are of the most unexceptionable character. The fine sextile portico at the eastern end is composed of columns having Corinthian capitals, with the usual entablature and pediment.

The tabernacle is, as we have before informed our readers, in the Classic style. No artificial material has been used, the whole of the exterior being of good stone. The plain surfaces of the walls are of Kentish-rag, and the entrance portico, together with the dressings of the doorways, windows, string-courses, and copings, of Box-hill Bath stone. The total length of the structure, measuring from the front steps of the chief entrance to the back wall at the west end, is 208 feet, and its width 106 feet. In addition to which width, externally, is to be added that of open areas at each side, in communication with the basement story. There is also an open area at the west end. The tabernacle, internally, including the vestries, all of which are planned on the ground-floor, is 174 feet long by 85 feet wide in the clear, exclusive of the portico. The internal height, from the basement level to the louvre light in the roof, is 89 feet. There are two tiers of spacious galleries entirely round the interior of the building, supported by a series of sixteen cast-iron columns, extending from the basement, standing firmly on brick pillars with concrete foundations.

Instead of the pulpit being placed near the wall at one end, as is generally the case, a tribune (if it may be so called), is projected from the western end, 29 feet long by 26 feet wide, and 4 feet high from the main floor line of the chapel. This tribune has a semicircular front on which the pulpit will be fixed, which arrangement it is expected will enable the whole of the congregation to both see and hear the preacher. With the idea of aiding the acoustic qualities of the edifice, no plaster work will be put on the walls, instead of which they are being entirely lined with wood. In the basement there is a large lecture-hall, together with a school-room and convenient class-rooms.

The works have been executed in a creditable manner by the contractor, Mr. W. Higgs, under the superintendence of the architect, Mr. W. W. Pocock. The building with its extensive galleries is arranged to accommodate from 9000 to 10,000 persons, all of whom, it is believed, will be able to see and hear the minister. It is expected that the chapel will be opened in two or three months from this time.

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NEW PREMISES OF THE LONDON PRINTING AND PUBLISHING COMPANY.

(With an Engraving.)

THE new and important building, the principal entrance and part of principal front of which (in St. John-street, Smithfield) is shown in the accompanying engraving, occupies a rectangular site, with a frontage of 52 feet in St. John-street, and of 70 feet in Charterhouse-lane. The height to ridge of roof from the basement is 91 feet, from ground level 84 ft. 6 in., and comprises with the basement seven stories. The principal entrance forms the centre of the five bays into which the St. John-street front is divided.

The accommodation provided is, in the basement, for a steam-boiler, coal store, vaulted fireproof room for stereotype plates, and paper and ink stores. On the ground-floor are, the steam-engine, counting-houses, and sale-room. On the first-floor, board-room, secretary's room, four authors' rooms, and store for book stock. On the second-floor, provision is made for bookbinding; and on the third-floor for stock and lithographic printing. On the fourth floor also for stock, and steel and copper plate engraving; and on the fifth floor for copperplate printing. The workmen's entrance is in the last of the seven bays in Charterhouse-lane, and leads to a fireproof stone staircase: urinals, water-closets, and washing-places are provided for each story on the landings of this staircase. A lift worked by steam communicates with each floor from basement to top of building. A cast-iron tank for 4000 gallons of water is placed in the roof, with firemain, cock, and hose to each floor.

The materials employed are ground Box stone, red Kent facings and cutters, and Ewell black rubbers; blue Staffordshire bricks for external plinth, and for massive piers under two rows of iron columns which run from front to back of the building, carrying the wrought-iron girders: these columns and girders are repeated in each story. Ventilation is secured by flues in the side wall, which communicate with each floor. The windows are fitted with Moline's patent wrought-iron sashes and obscured plate glass; the upper portions of them turning on centres. The interior is necessarily perfectly plain. Externally the building well portrays its purpose. It is principally of red brick with occasional bands of black brick. The style may be denominated German Gothic, treated with much originality. In the finial over the principal door is carved the head of Guttenberg: those of Scheffer and Faust form the terminals to drip-moulding of same. The head of Caxton surmounts the workmen's doorway.

The architect is Mr. J. Somers Clarke, of Cockspur-street, London, who has constantly superintended its erection; Messrs. Kirk and Parry, the contractors; and Mr. Jane, the clerk of the works. The carving was executed by Mr. Thos. Earp.

IMPROVEMENTS AT THE NATIONAL GALLERY.

AT the National Gallery important alterations have been commenced, by which considerable additional space will be obtained; a sum of £15,000 having been voted for the purpose last session. The alterations are being made from the designs of Mr. Pennethorne, but modified from those furnished by him in the first instance, to meet the administrative requirements of the establishment. It is necessary to state this distinctly, as it has been announced in several publications, that it is the plan prepared by Captain Fowke which is being carried out. But Captain Fowke's plan differs in every particular from that actually adopted. It proposed much more extensive changes in the building, both externally and in the interior: the removal of the Royal Academy from the east to the west wing, and the appropriation of the greater part of the basement as exhibition rooms. All these, its leading features, were regarded as objectionable by the authorities. The Government demurred on the score of the probable expense. The Royal Academy protested against their enforced removal. The Keeper of the National Gallery pointed out the absolute necessity for retaining the basement rooms for administrative purposes. In the plan actually adopted the basement rooms are retained; the Royal Academy is undisturbed; the exterior of the Gallery is essentially unchanged: in a word, the alterations are confined to the centre of the building.

The grand feature of the alterations is the appropriation of the Central Hall to exhibition purposes. Our readers will remember this huge, sombre, central hall, the Waterloo Vase its solitary tenant; and perhaps will be able to recall the equally spacious and scarcely more cheerful side halls, from which the broad staircases led on one hand to the National Gallery, on the other to the Royal Academy. But only by standing on the spot, now the walls have been swept away, and its whole area laid open to the sky, could any distinct conception be formed of the enormous space which these halls and staircases occupied. No less, in fact, than 170 feet of the 450 which form the entire length of the building have been demolished. In other words, of the entire building the great hall and staircases consumed very nearly 2-5ths the other 3-5ths being divided between the National Gallery and the Royal Academy: and when the confined extent of the building is remembered, and the extreme value of exhibition space, the marvellous absurdity of such an appropriation becomes manifest.

On the site of the halls will be constructed two exhibition rooms: one on the basement, which will form the new Sculpture Room for the Royal Academy Exhibition; and one above, on a level with the present rooms of the National Gallery and Royal Academy, which will form a saloon for the most important Italian pictures in the National collection. This Italian Saloon will be a room of stately proportions, being 75 feet long, 31 broad and 35 high. It will be lighted by an oblong dome, the upper half of which will be of rolled glass; thus, whilst affording ample light, rendering screens unnecessary. This room will give what has hitherto been greatly wanted—a grand central feature to the gallery; and when it is filled with our finest Italian pictures, and the largest of the present rooms (in which the Italian pictures have hitherto been hung) is filled with the Flemish pictures, to which it is to be appropriated, our National Gallery will produce an impression far beyond what would be generally anticipated.

The entrance to the gallery will be by a flight of stairs on the left of the entrance hall, and very near the door. These will lead directly into the southern room, now appropriated to paintings by the early masters. The passage dividing this room from the corresponding northern room will be removed, and the latter will be consequently increased some 11 feet in width. East of this will be a vestibule with a circular light, and through this vestibule admission will be gained to the new Italian Saloon. The rooms to the west remain, as we have said, essentially unaltered; but the entrance to the first of the large rooms, instead of being, as at present, by the great central doorway, will be by two doors, one from each of the smaller rooms just noticed. The vista will thus be destroyed; but there will be the gain of the limited extent of the gallery not being exposed at the first glance, and a large well-lighted wall space will be obtained.

We have described, we believe, all that is gained for the pictures; but there are various new arrangements which will afford the public considerable additional accommodation. The room gained by these alterations will furnish ample space for the foreign pictures at present possessed by the nation, and for considerable future purchases. This, however, would merely tide over a difficulty for a few years. It has been provided therefore, in making the alterations on the side of the Royal Academy, that they shall be similar to those of the National Gallery, so that, when the Academicians vacate their rooms, it will be easy at once to convert the whole building, at a very small additional expense, into a connected suite of galleries, having a handsome entrance hall, a grand central saloon for the choicest pictures, two other great rooms at the extremities of the building, with enough secondary rooms to contain a collection as extensive as is likely to be formed for a long course of years, and to admit of their due classification. The present extension will, however, allow of a very marked improvement in the classification of the pictures, as well as their more convenient display.

The gain to the Royal Academy by the alterations will be chiefly in the sculpture department. The new room, mentioned above, will be the same size as the new Italian room of the National Gallery (75 feet by 31), and will, of course, be pure gain; but a new room will also be erected on the foundations of the old Sculpture Room, but more elliptic in form and better lighted than the former inconvenient "den." Further, as the entrance will be similar to that of the National Gallery, there will be obtained some small additional picture space. Altogether, although if an entirely new building were being erected, something should be produced very different to what the present structure could be made by any conceivable alteration, it must be admitted that what is being done is, so far as it goes, a clear gain, and, for the amount of expenditure, a very remarkable one.

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HOLY TRINITY CHURCH, HULL.

THE erection of this church was commenced, according to the most authentic accounts extant, about the year 1285. It is one of the largest parish churches in England, covering an area of 25,640 superficial feet. For many years it has been in a most dilapidated condition, and in some parts it is ruinous, notwithstanding the efforts which have been made at various times to preserve and restore it. The necessity for a thorough repair of the whole fabric having at length become inevitable, a restoration committee has been appointed, who have selected as their advising architect Mr. G. G. Scott, of London.

The building evinces three different periods in its construction. The transept is of the time of Edward II., and probably a chancel on a smaller scale than at present was added at the same time, the early addition of a collegiate body demanding in the succeeding reign the erection of a greatly enlarged choir. But, be this as it may, the existing chancel unquestionably belongs to the middle of the fourteenth century, and the chapels along its southern side are nearly coeval. The lower part of the tower is of the original structure to the height of a few feet above the roof of the church. The nave, with the upper stages of the tower, is of later date, probably the early part of the fifteenth century, although certain histories place it later: possibly it may have been increased in length at a later period without changing the details. All the earlier portions were of brick, with stone dressings; the later wholly of stone.

There does not appear to have been any serious settlement or failure in the walls, with the exception of the tower. This has been found to be built upon a vast raft of oak trees, crossing one another at right angles. The trees are said to be still sound, but the platform has sunk unduly towards the south, and some of the trees have been broken by the pressure. This was, no doubt, a settlement of an early origin, but it has continued to, or nearly to, the present age; and the consequence has been the fracturing, to a considerable extent, of the surrounding arches and of the clerestory walls, a serious southward inclination of the tower piers, and some large cracks in the east and west walls of the tower itself. There is little doubt but that this settlement commenced before the completion of the tower, and suggested the extreme lightness of the walls of the upper story, and the adoption of timber framing to give them additional strength.

The great want of restoration, however, is in the external stonework, which has more or less perished throughout the entire building, so much so as in many parts to require the entire renovation of the exterior. This was some years past commenced on the east and north sides of the chancel, and in the transepts; but of these some parts have been executed in Caen stone, and have again perished. The pinnacles have, more or less, disappeared throughout the church; the parapets are also in a very bad state, as is also by far the larger portion of the general stonework of the church. The curious and interesting series of chapels along the south side of the chancel are in a state of absolute ruin, and if restored will become very useful for vestries and monumental chapels, adding much to the interest of the building. Portions of the foundations of the main walls will have to be underpinned and rebuilt; this is in some measure owing to the formation of vaults, for which the ground has been excavated to the depth of several feet below the foundations, without taking the precaution of underbuilding them.

The estimated cost of the restoration, which is to be proceeded with immediately, was stated by the architect at from £10,000 to £12,000, embracing the following items, and supposing the roof timbers to necessitate a moderate amount of reparation :

1st. The arches abutting against the tower to be repaired and strengthened; a strong system of iron ties introduced into the tower at two stages of its height; and the timber-work of the tower, floors, &c., put in order.

2nd. The stonework throughout the exterior to be thoroughly restored, including the windows, buttresses, crockets, pinnacles, &c., and the re-opening of the south porch.

3rd. The south chapels to be restored.

4th. The roofs throughout to be thoroughly examined, and put in perfect order, within and without, and the lead renewed and repaired as may be required for the several portions.

5th. The glazing to the nave windows to be renewed.

6th. The ground to be lowered all round the church, and the foundations everywhere underpinned, and the drainage to be renewed.

STREET IMPROVEMENTS OF LONDON.

THE Victoria Railway Hotel, now in progress at Pimlico, will certainly take precedence of all others hitherto erected in the metropolis, not only with regard to size and internal conveniences, but also for the effectlve character of its external architecture and the great novelty of most of its details. The architect of this edifice, Mr. James T. Knowles, of London, boldly throwing off the trammels of precedent and copyism, will produce a structure that will be among the best architectural ornaments of London. The design combines most successfully French Renaissance and Lombardic elements, which are being worked out with great boldness of effect and much originality. The principal façade is upwards of 300 feet in length; the depth of the building is 83 feet. The block is planned with a tower at each end formed of seven stories, and crowned with pavilion-shaped roofs: the intervening portion consisting of six stories above the foot pavement, beneath which level there are spacious basements extending the whole area, to be devoted principally to culinary purposes. The principal fronts will present a massive and magnificent appearance, displaying great breadth of treatment, and divested of an excess of minute detail. The ground-floor is entirely cased with Bath stone in bold rustic work; the openings are semicircular-headed. Over the windows are suspended festoons of fruit and flowers in alto-relievo. Above the ground-floor is a balcony supported on moulded and ornamental cantilevers. Balconies will also project from the sills of the second and third floor windows. Most of the windows throughout the front are semicircular-headed, having their heads filled with perforated stonework in ornamental patterns. The tympana or spandrels between the arched windows of the first and fourth floors are embellished with circular moulded panels, within which will be carved in bold relief, on deep concave grounds, the portraits of illustrious personages. The fourth-floor openings are each divided by a pilaster into two lights within the arch openings, and have a very good effect. The upper cornices around the towers are at a greater altitude than those of the central block, and are supported by moulded consoles. The roofs are to be of the Mansard type, and when the boldly-projected dormers are inserted, will have an excellent effect in combination with the chimneys and ornamental cresting to the ridges. The chief entrance is in the centre of the principal elevation by means of three arches, which give access to an inner loggia 35 feet by 8 feet; this loggia leads to a large central hall, 45 feet by 30 feet, at the rear of which is the grand staircase, the ceiling of which is to be elaborately decorated in plaster-work, and supported by sixteen columns with enriched capitals. In the basement, at one end, is a kitchen 36 ft. 4 in. by 38 ft., in direct communication with which there are a larder, pantries, plate-closet, &c. At the other end of the basement is a servants' hall, and a dining-room for visitors' servants, each 25 feet by 20 feet; there is also a housekeeper's and butler's room, together with a linen store, wine and beer cellars, &c. The communication in the basement is by a corridor, nearly 14 feet wide, which runs in the centre of the edifice, with the necessary branches leading from it. The same mode of communication is also observed on the ground-floor. At the north-eastern end of the ground-floor are a coffee-room 70 feet long by 36 feet wide, and a smoking-room 39 feet by 23 feet. At the other end are a ladies' dining-room and coffee-room, each measuring 37 feet by 26 feet, and a drawing-room 25 feet long by 14 feet wide, with a boudoir attached. The grand staircase will form a peculiarly magnificent feature of the interior. On the first-floor level it will assume additional size and importance by its area being set back 8 feet, by which it will embrace a space of 62 feet by 47 feet, and thus will, we believe, be the largest staircase in London. The whole of the first floor is divided into suites of apartments, comprising dining and drawing rooms, sitting-rooms, bed and dressing rooms of various sizes, some of the former measuring 36 feet by 26 feet. On the second and third floors a similar arrangement is to be observed, adapted to a less wealthy class of occupants. The fourth, fifth, sixth, and seventh floors are to be adapted for bed-rooms, dressing-rooms, and bath-rooms. This vast structure will contain upwards of 500 apartments. The basement is 12 ft. 6 in. high in the clear; the ground-floor 18 ft. 4 in.; the first, 16 ft. 6 in.; the second, 13 ft. 3 in.; the third, 11 feet; and the fourth floor, 12 feet.

As a matter to be expected in the construction of so large a building as that which we have briefly described, great difficulty occurred in securing a good foundation, more particularly in the

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particular locality of Pimlico, where, as at Westminster, the strata consist of quick sands, mud banks, and old peat bogs, which overlay the London clay. This difficulty has been overcome by the energetic contractor for the works, Mr. John Kelk, by the aid of immense masses of concrete, in some instances 40 feet in thickness. The lower layer of this concrete, 3 feet in depth, is composed of ballast and Portland cement, thus preventing the ascent of damp. The upper layer, after the inequalities were brought to a level, is 7 feet in depth, and was made of a mixture of ballast and grey stone lime crushed from the clod. As we have already observed, the whole of the ground-story portion of the building is cased with Bath stone; above this level the walls are faced with white Suffolk bricks, and the dressings of the windows, together with the various string-courses, cornices, and parapets, are of Bath stone of the best quality.

Another important structure now in progress is the Buckingham Palace Hotel, situated on the southern side of the Victoria-road, and nearly opposite the southern end of Buckingham Palace. This edifice embraces the large area of 147 feet by about 70 feet. The height of the elevation from the roadway level to the top of the parapet is 71 ft. 3 in. The exterior presents an exceedingly well-designed façade in the Italian style. All the windows are square-headed, and have well-proportioned dressings. At the sills of the first and second floor windows balconets are projected, the fronts of which are embellished with open balustrading of light and appropriate design. The uppermost stories are of a plainer character, and are surmounted by a cornice, enriched with dentils and moulded blocks, the latter of which support its corona. Above this cornice is a balustraded parapet, and, in the roof, dormers. The chimney-shafts harmonise in design and detail with the principal elevation. As at the Victoria Railway Hotel, a considerable quantity of concrete was necessarily used in forming the foundations, the lower strata of the site being of a treacherous nature, involving the employment of concrete 12 feet in depth, upon which footings of brick are built, set in Portland cement, and as a further security from settlements, inverted arches have been turned over all openings. The arrangement of the interior is very complete. In the basement there are two kitchens at the west end, each 47 feet by 27 feet, supplied with cold air by flues connected with the area in the street, and admitted through gratings fixed in various positions of the floors. The ceilings of the kitchens are formed of segmental arches of three thicknesses of tiles set in cement, and supported by wrought-iron girders, being thus rendered fireproof. In the centre of each of these arches gratings are to be fixed to pass off the hot air and steam, in flues communicating with hot-air shafts on each side of the kitchen-ranges. The smoke-flues from the kitchens are 15 inches diameter, and are constructed of galvanized wrought-iron. They are carried the whole height of the building, and are fixed within hot-air shafts 3 feet by 2 feet, insuring good ventilation throughout the structure. The communications from the kitchens to the serving rooms will be by means of a double lift. In immediate connection with the kitchens are a visitors' servants' room and ladies-maids' room. The domestic offices, wine and beer cellars, bakery, larders, and other offices, are at the eastern end of the basement. There is a servants' staircase at each end of the edifice, independent of the principal one. These staircases extend from the basement to the fourth-floor. There is also a lift at the eastern end for the hoisting of coals, luggage, &c. On the ground-floor there is a coffee-room 44 feet by 27 feet, with a reading-room adjoining, a sitting-room 25 feet by 27 feet, and two others of smaller dimensions, together with a commodious bar, bar-parlour, still-room, bath-rooms, waiters' and porters' rooms. The principal staircase has an area of 24 feet by 16 ft. 6 in., and 59 feet in height from the ground-floor to a sky-light in the roof, from which it will be lighted. The corridor of communication on the ground-floor is 9 feet in width, with a vaulted ceiling in brickwork set in cement, and will be lighted by two pendentive lights. The floor above is laid with Portland stone pavement. On the first-floor are seven sitting-rooms averaging in size 20 feet by 18 feet, five bed-rooms with dressing-rooms adjoining, and linen and housemaids' closets, &c. On this floor the corridor takes a somewhat different position, in order to give greater depth to the rooms at the rear, and also for the admission of light over the pendentives before mentioned. The floor of this corridor is supported by iron girders running from east to west. These girders are covered as a floor with Portland stone paving. The arrangement of the second floor is precisely the same as that of the first. The attics will be occupied by numerous bed-rooms: in these the position of the communicating corridor is again altered, with the view of obtaining more light from two open courts that are introduced in the plan for the purpose of securing light and ventilation. These courts have each an area of 36 feet by 9 feet. The heights of the different stories from floor to floor are—the basement, 11 ft. 1 in.; ground-floor, 18 ft. 3 in.; first-floor, 14 ft. 6 in.; second-floor, 14 ft. 3 in.; third-floor, 12 ft. 1 in.; and the fourth-floor, 10 feet.

In designing this building the architect, Mr. James Murray, of Portman-street, London, in addition to the elegance of its façade, has evidently much studied its construction and convenience. Ventilation is provided for by two shafts constructed in the vestibule, having a supply of cold air from the area, and connected with the coffee and reading rooms, escaping by perforations in the skirtings. Messrs. Lucas, Brothers, of Lambeth, are the contractors.

SUSPENSION GIRDER BRIDGES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—In an article on the above-mentioned subject in your *Journal* for this month I find the passage—"It might have been of great help in such an inquiry to have been made acquainted with the course of reasoning pursued by Prof. Rankine," etc.

The only investigation on the subject which I have published is contained in 'A Manual of Applied Mechanics,' pp. 370–5. It proceeds on the assumptions, that the girder is *fastened down* as well as *supported* at the ends, and that the disfigurement of the chain is too slight to affect the distribution of the tension on the suspension-rods to an extent appreciable in practice. As I see that your investigation sets out by considering the disfigurement of the chain, I await its continuation with interest. I hope soon to be able to publish a demonstration that the results of my investigation on Mr. Barlow's suspended girder are applicable, with some slight modifications, to Mr. E. A. Cowper's proposed *tension ribs* for suspension bridges.—I am, &c.

Glasgow, Nov. 24, 1860. W. J. MACQUORN RANKINE.

P.S.—The following results of your investigation and of mine present a pretty close agreement, notwithstanding the difference of our methods. A load (W) being hung from the middle of a span of a suspended girder, the distributed pressure thrown on the chains is,

According to your investigation (page 319) $\frac{25}{16}W = 1{\cdot}5625W$.

According to mine (page 372) ... ... 1·577W.

New Metropolitan Railway Projects.—Surveys are in progress for the construction of an underground railway, commencing at Regent-circus, Oxford-street, and terminating at the station of the Metropolitan Railway in Victoria-street, Holborn-bridge. The line will not pass under the principal thoroughfares, as does the railway now being constructed, but will take a route to the south of Oxford-street and Holborn. Another new railway project, which excites some interest in the City, is a scheme for directly connecting the Bank and Charing-cross. This connection is not sought to be obtained by any street railway such as that proposed by Mr. Train, but by means of locomotive railway; passengers to be conveyed from Charing-cross to the Bank in about six minutes, in trains running at intervals of five or ten minutes during the day. The proposed railway will connect the Charing-cross line directly with the City by means of a bridge across the Thames at a point where the river is at the narrowest, about midway between Southwark and London bridges, and carry the line thence to the back of the Mansion House, or to Cannon-street. The distance from a point immediately behind St. Saviour's Church, Southwark, to Cannon-street, is only about 800 yards. This is said to be practically the whole length that will have to be constructed in order to bring the Bank and Charing-cross within five minutes of each other. A return has been issued by the Board of Trade, made up to the end of last year, showing the financial condition of the railways of the United Kingdom. The total capital raised is stated at £334,362,928. It increases by several millions every year, part of the new capital being laid out in heavier rails, larger stations, and additional rolling stock, and the rest absorbed by new lines.

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THE ROYAL POLYTECHNIC INSTITUTION AND ARCHITECTURAL CLASSES.

This Institution, always a favourite with scientific men and with the public, and of which we have already in past years had occasion to take favourable notice, is now afloat again, after having been for a time closed in consequence of the results of a melancholy accident that will be fresh in the minds of our readers. There are few who will not be glad to see an old friend returning to activity, and will not wish that the success of the effort may be complete.

Various improvements have been effected; the building has been decorated and renovated, and many new articles of interest have been added, some of which we may describe on some future occasion. At present we wish to refer to an experiment proposed to be tried in the Educational department. It will be remembered that for some time past classes, both morning and evening, have been held in rooms on the premises, and forming a separate department of the Institution. The success of some of these, especially those for the study of chemistry, has been very great.

The directors, we are informed, are about to announce their intention of opening classes for systematic practical instruction in Architecture and Construction, and should that announcement be responded to at all cordially, so as to show them that they were not mistaken in believing these classes would be well received, a commencement will be made at once.

At present there exists in London a large body of young men, the pupils and assistants of architects, of engineers, of contractors, and the better sort of workmen, to whom some instruction in architecture of an academical character is essential, or almost essential; and there are practically but two sources from which to obtain it, the classes at the two colleges—King's College and London University College;—for the lectures at the Royal Academy form in no sense a course of study, any more than can the opportunity which the Institute affords to *its* students of using the library and being present at the meetings. The classes at the two colleges stand high, especially that at London University, the only one much attended by persons not otherwise connected with the University or the College. In the belief, however, that the expense, and the length of the course of lectures, place them beyond the reach of some, perhaps, who would gladly attend a shorter course, with a smaller fee, it has been proposed to form these classes. A gentleman competent to direct them has been appointed, and students are invited. This is an opportune time, for the agitation on the matter of examinations and diplomas now going on will turn attention to the subject of education—and not before it is wanted, for we are lamentably deficient in that particular; and many a youth, who might have done well in the profession of an architect, has done badly for want of sufficient instruction to incite him to study, and to point out to him what books to consult. We commend the idea to our readers, and bespeak their support for the Polytechnic Institution, both in its spirited effort to surmount bad fortune and to continue to afford those opportunities to the public that for so long have been offered, and also in this its new attempt to extend its usefulness and to benefit the younger members of those professions to whom this *Journal* specially addresses itself.

SUSPENSION GIRDER BRIDGES FOR RAILWAY TRAFFIC.

(*Concluded from page* 319.)

The case in which a single concentrated load produces the greatest wave, and causes the greatest strain to be thrown on the girder, is when it is placed at a distance midway between the half-span and one of the towers. A load of 256 cwt. placed in this position causes a distributed pressure on the chains equal to 285 cwt. This excess of 29 cwt. is due to the reaction of the further end of the girder, which is supposed to be fixed down to the pier by rollers, as it would otherwise be lifted from its seat by the tension of the chains. Let us compare the wave caused by a weight in this position with the deflection which the same weight would produce if placed in the centre of the girder, the support of the chains being withheld: w being the weight, and k the constant already referred to, $-kw \times \frac{s^3}{48}$ is the deflection which would follow were the girder not suspended, and the weight placed in the centre. To facilitate comparison we will therefore express the ordinates of the wave now under examination in terms of $\frac{kws^3}{48}$.

First, the simple wave of deflection will have for its ordinates,

at the loaded quarter-span ... ... $-0{\cdot}5625 \times \frac{kws^3}{48}$

at the half-span ... ... $-0{\cdot}6875 \times \frac{kws^3}{48}$

and, at the opposite quarter-span ... $-0{\cdot}4375 \times \frac{kws^3}{48}$

The reflex wave will have for its ordinates,

at the loaded quarter-span ... $+0{\cdot}4959 \times \frac{kws^3}{48}$

at the half-span ... ... $+0{\cdot}6958 \times \frac{kws^3}{48}$

at the opposite quarter-span ... $+0{\cdot}4959 \times \frac{kws^3}{48}$

The addition of these ordinates will give the following as the ordinates of the resultant wave:—

at the loaded quarter-span (a depression) $-0{\cdot}0666 \times \frac{kws^3}{48}$

at the half-span (a rise) ... ... $+0{\cdot}0083 \times \frac{kws^3}{48}$

at the opposite quarter-span (a rise) ... $+0{\cdot}0584 \times \frac{kws^3}{48}$

The greatest deflection is therefore $-0{\cdot}0666 \times \frac{kws^3}{48}$ or $\frac{1}{15}$th of the deflection due to the same load placed on the middle of the girder without chains. This result has however to be increased by the correction for the stretching of the chains.

The preceding result cannot be directly compared with those given by Mr. Barlow's experiments, because the reflex wave in his model is affected by the inequality in the height of the towers, which is such as to increase this wave by $\frac{1}{7}\frac{1}{3}$rd part when the load is placed one-fourth of span from the high tower, or to reduce it by the same amount when the load is placed one-fourth of span from the low tower. We will therefore take the mean of two experiments with the first girder, the load being 56 lb.; in the first case placed at quarter-span from the high tower, and in the second case at quarter-span from the low tower; and compare the mean so obtained with the deductions of theory.

The girder experimented on was one which without the chains deflected 1·2 inch when a load of 42 lb. was placed on the centre. In this instance, therefore, $\frac{kws^3}{48} = \frac{1{\cdot}2}{42} \times w = \frac{w}{35}$. For the load of 56 lb. at the quarter-span we have therefore to multiply the coefficients of $\frac{kws^3}{48}$, as above determined, by the fraction $\frac{56}{35}$, or $\frac{8}{5}$, in order to obtain the ordinates, in fractions of an inch. The following is a comparison of the results:—

	Theory. inch.	Experiment. inch.
At loaded quarter-span ...	Depression, $-0{\cdot}107$	Depression, $-0{\cdot}110$
At half-span	Rise, $+0{\cdot}013$	Depression, $-0{\cdot}010$
At opposite quarter-span .	Rise, $+0{\cdot}093$	Rise, $+0{\cdot}055$

With a load of 168 lb. placed at the quarter-span, taking the mean of two experiments as before, we get the following results:—

	Theory. inch.	Experiment. inch.
At loaded quarter-span ...	Depression, $-0{\cdot}320$	Depression, $-0{\cdot}320$
At half-span	Rise, $+0{\cdot}040$	Depression, $-0{\cdot}065$
At opposite quarter-span...	Rise, $+0{\cdot}280$	Rise, $+0{\cdot}170$

In glancing at these figures an exact correspondence is noticeable between theory and experiment in the amount of depression at the loaded quarter-span. We must not however allow ourse ves to be deceived by an identity of result, which arises from a compensation of opposite disturbing causes. It is evident that the form of wave in the model is different from that of the calculated wave; that the centre is depressed, instead of rising; and that, while theory gives 0·60 inch as the sum of extreme depression and extreme rise, experiment reduces this sum to 0·49 inch.

One element of this difference is to be sought for in the stretch-

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ing of the chain in the model, which causes a deflection at the centre of the girder, and elongates and deepens the wave of depression, at the same time that it reduces the wave of elevation. The other element of difference lies in the resistance of the chain itself to a change of position, a resistance very noticeable in a heavily-weighted model with an exaggerated wave, but omitted in our theory; the error involved in the omission being one on the safe side. The operation of this cause in modifying and reducing the total wave (as measured from extreme deflection at one quarter-span to extreme elevation at the opposite quarter-span) may be traced in the successive experiments made by Mr. Barlow, in which the distributed load on the platform was gradually increased to 193 lb. In this set of experiments the girder was a plank 7½ inches by ¾-inch, the deflection of which without the chain was 1·48 in. with 10 lb. A weight of 56 lb. was placed at quarter-span from the high tower. The displacements according to theory, after correction for the unequal height of the towers, should be as follows:—

	inch.
At quarter from high tower	—0·496
At half ,, ,, ...	+0·148
At three-quarters ,, ...	+0·540

The actual displacements with no distributed load on the platform were

At quarter from high tower	—0·48
At half ,, ,, ...	—0·02
At three-quarters ,, ...	+0·29

But with a distributed load of 193 lb. placed on the girder, the displacements caused by the 56 lb. weight became reduced to the following:—

At quarter from high tower	—0·31
At half ,, ,, ...	+0·05
At three-quarters ,, ...	+0·20

As might have been expected, the more the wave is magnified in the model, by reducing the rigidity of the girder, the more widely the actual displacements differ from those of theory; owing to the resistance of the chain to these exaggerated displacements becoming more appreciable. Thus, for the girder which deflected without the chains 2·375 inches under a load of 8 lb., if we take a mean between the results given by 56 lb. placed at one-fourth from the high tower, and the same weight placed at one-fourth from the low tower, we find the calculated and the actual displacements to be respectively as follows:—

	Theory. inch.		Experiment. inch.
At loaded quarter-span	—1·108	.....	—0·855
At half-span	+0·138	.....	+0·160
At opposite quarter-span	+0·971	.....	+0·780

The result of the experiments in this instance is very diverse from those of the preceding experiments, especially in the proportionate largeness of the wave of elevation, which in fact seems anomalous.

On the whole, the comparison of these experiments with the results of calculation considerably confirms the accuracy of the theoretical formula, as applied to the small actual displacements of a full-sized bridge. It must however be remembered, that it has been assumed that the flexibility of the girder is everywhere uniform, and the same for upward as for downward pressure—conditions not always found in a plank, such as took the place of a girder in Mr. Barlow's model: and assumed, further, that the girder is not continued nor weighted for any distance beyond the face of the piers.

According to the calculated coefficients, a concentrated load at quarter-span from one tower will cause a depression of 0·0666, or $\frac{1}{15}$th the deflection which the same load without the chains would cause if placed at the centre of the girder. This depression will be accompanied by a rise at the opposite quarter-span of 0·0584. The depression will be increased, and the rise diminished, by the stretching of the chains. The sum, which will not be affected by the stretching of the chains, is 0·1250, or ⅛th.

Let us now pass on to the consideration of the condition which imposes the severest possible strain upon the suspended girder, namely, the distribution of a load over half the girder next one tower. Here we have no experiments recorded that supply any check to theoretical calculation. We may however the less regret the omission, when we find that the condition just supposed is the one in which the problem assumes its very simplest form.

We have already presented the result of the investigation of the effect of the concentrated weight w placed on the suspended girder, at a point whose distance d from the centre bears to the entire span s the ratio $\frac{d}{s} = r$. We found that the load thrown on the chains would be

$$\left(\frac{25}{16} - \frac{15}{2}\, r^2 + 5r^4\right) \times w\,;$$

and thence deduced the ordinate of the reflex wave. If for a concentrated load at one point we substitute a load equably distributed between two points (at the respective distances $d = rs$, and $d_2 = r_2 s$, from the centre), the rate of loading per foot forward being denoted by m, the load thrown on the chains will be readily found by integration to be equal to the following expression:—

$$\text{Load on chains} = \left(\frac{25}{16}\,(r_2 - r) - \frac{5}{2}\,(r_2^3 - r^3) + r_2^5 - r^5\right) \times ms.$$

And when one half-span is equably loaded, and the other half-span not loaded—that is to say, when $r_2 = \frac{1}{2}$ and $r = 0$, we find that

$$\text{Load on chains} = \left(\frac{25}{16} \times \frac{1}{2} - \frac{5}{2} \times \frac{1}{8} + \frac{1}{32}\right) \times ms = \frac{ms}{2}$$

which is exactly the amount of the load distributed over the half-span of the girder.

A load therefore, say of 100 tons, distributed over half the span of the suspended girder, induces an upward reaction in the chains equal to 100 tons distributed over the whole span. The unloaded half of the girder will therefore have to sustain an upward distributed pressure (from the chains) equal to 50 tons; the loaded half of the girder will have to sustain the difference between its load of 100 tons and the upward reaction of the chains, which will be 50 tons: this difference amounts to 50 tons, and is the net downward distributed pressure on the loaded portion of the girder.

It is therefore obvious that, apart from the stretching of the chains, the suspended girder will in this case assume a perfectly symmetrical S curve; the upward flexure of the unloaded half of the girder being exactly similar and equal to the downward flexure of the loaded half. The same result is arrived at by combining the simple wave of deflection with the reflex wave.

It thus appears that, *for a bridge of a single span only*, the greatest strain which a given rolling load can throw on the suspended girder is ½th of the greatest strain which it would throw on an ordinary girder not suspended.

Take, for instance, a bridge of 400 feet span, with a rolling load of 1 ton per foot forward. For a common girder bridge the greatest strain will be that which is sustained at the centre when the whole bridge is loaded; and will be represented by the product of 400 (the load in tons), and 50 (the eighth part of the span). This product is 20,000. For a suspended girder the greatest strain will be that which arises at the quarter-span, when the half-span is loaded. The rolling load is in this case 200 tons; but as the upward reaction of the chains distributed over the half-span is 100 tons, the load sustained by the girder is only 100 tons. The strain will therefore be represented by the product of 100 (the virtual load in tons), and 25 (the eighth part of the half-span). This product is 2500, which is ½th of 20,000, the greatest strain on the simple girder bridge.

We have hitherto postponed the consideration of the stretching of the chains when the rolling load comes on the bridge, and the consequent depression of the reflex wave. Let us suppose a uniform elongation of the chain, at the rate $1 : 1 + e$; and s being the span, let v be the rise of the curve of the chains; then $\frac{25e}{32}\left(\frac{s^2}{4v} + \frac{4v}{3}\right)$ is the expression for the settlement at the half-span due to the assumed amount of stretching of chain; and this will be the consequent diminution of the sagitta of the reflex wave.

The rise or fall of the girder occasioned by the contraction or expansion of the chains on change of temperature is expressed in a form identical with the preceding; and the consequent strain on either flange of the girder can be readily computed when the depth of the girder is known. And when the section of the girder is known, it will be easily ascertained what amount of additional load is thrown upon it, from the deflection attending the stretching or the expansion of the chains.

In brief, for a bridge of a single span, the section of the sus-

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pended girder should be calculated to give $\frac{1}{8}$th, not of the entire strength of a simple bridge girder for the same span, but of so much only of its strength as is assigned to the support of the maximum rolling load. This distinction is one of great moment where heavy spans are encountered, and indicates the extreme economy of the suspended girder in such cases. All the fixed dead weight, inclusive of the weight of the girders themselves, is carried by the chains; with the exception that, when these expand or are stretched, a small distributed load is thrown on the girders. A *small* distributed load, because a girder of the proportionate strength required, and of a depth from one-third to one-half of the rise of the chains, will readily rise and fall to the necessary extent, without sustaining much strain. The girders could, moreover, be strained up to a camber, in fixing, so as greatly to reduce the downward strain resulting from the elongation of the chains.

As an illustration of this, let us suppose that the chains of a bridge of 400 feet span have a rise of 50 feet, and carry a girder of such rigidity that a distributed load of 50 tons would cause it to deflect 10 inches, were the support of the chains withheld. If a rolling load of 400 tons, covering the whole bridge, causes the chains to stretch $\frac{1}{2000}$ part of their length, the resulting deflection will be 4 inches: but the girder in deflecting 4 inches has a distributed load of only $\frac{4}{10} \times 50$, or 20 tons, thrown upon it, leaving 380 tons as the share of the rolling load sustained by the chains. And were the girder strained up in fixing to a 4-inch camber (representing an upward pressure of 20 tons), the effect of the stretching of the chains would be simply to release the girder from its forced camber, so as to leave it free from strain when the bridge is covered with its maximum rolling load.

Apart from the deflection or settlement alluded to, the maximum rolling load will cause an extreme deflection at the quarter-span, equal to $\frac{1}{3\frac{1}{2}}$ of the deflection which would take place at the centre of the same girder, under the same rolling load, without the chains; or about $\frac{1}{4}$th of the extreme deflection of an ordinary girder bridge of the same span and same depth of girder.

The case of the suspended girder, for a single span, having been thus far investigated, we may proceed to examine how the conditions become modified when there are more spans than one. If we suppose that, of two adjacent spans, one is loaded and the other not, we find that the chains on the opposite sides of the intervening pier will in the first instance be in very unequal states of tension, and that the one chain must sink and the other rise, until the equilibrium of tension is restored. This is presuming that the chains are connected, as is usual, by means of a saddle placed on rollers, so as to admit of such adjustment, and relieve the pier of any horizontal strain.

The necessity of this or some equivalent precaution, becomes manifest when we consider the nature of the horizontal strain that would otherwise be thrown on the pier or tower intervening between an unloaded and a loaded span. Take for instance two adjacent spans, each of 400 feet, of which one has only its fixed dead load, while the other is covered by a rolling load of 400 tons. If the rise of the chains be 50 feet, the horizontal tension of the one pair of chains will exceed that of the adjacent pair by 400 tons; so that, if the summits of the chains were made fast to the top of the tower (instead of being allowed to slide upon it), the tower would have to sustain a horizontal pull of 400 tons, tending to draw it over into the loaded bay. Could an ordinary pier be trusted to sustain a strain of this nature and magnitude, the foregoing part of our inquiry would be as applicable to bridges consisting of two or more, as to those of a single span; but prudence is generally considered to demand the exemption of masonry piers from such a formidable horizontal strain. Where iron is substituted for masonry, and a very extended base given, the towers might possibly be made to sustain a strain of this nature. But in such a case the summits of the towers would cease to be absolutely dead points, since unequal compression in the iron would inevitably cause a slight horizontal deflection towards the more heavily loaded span. This deflection, or swaying, of the tower, if only a few inches, would cause such a deflection in the loaded girder as we wish to avoid. We may therefore pursue our investigation into the case of two adjacent spans unequally loaded, the chains being allowed free play on the top of the intervening pier.

The function of the suspended girders will now be to equalise the strain on the chains, so as to insure equilibrium, before the deflection of one span and the drawing up of the other (which without the girders might be objectionably great) exceed some small fixed limit. If therefore, one span being unloaded, the adjacent span is covered with a rolling load of 100 tons, the action of the girders must be such as to throw a distributed load of 50 tons on each set of chains. The girders of the loaded span will therefore have to sustain a sensible load of 50 tons, the remaining 50 tons of rolling load being borne by the chains. At the same time, in the unloaded span, the reaction of the chains will distribute an upward pressure of 50 tons over the girders. These results will of course be modified by the stretching of the chains, which will diminish the rise in the one span, and increase the deflection in the other. It is perhaps hardly necessary to remark, that as the waves in the adjacent spans are of opposite kinds, they will in no way be affected by continuity in the girders.

For a suspension bridge of more spans than one, designed for railway traffic, it therefore appears essential to provide girders capable of sustaining a distributed load equal to half the maximum rolling load. These girders should not be of a depth exceeding from one-third to one-half the rise of the chains. For large spans—and it is for large spans only that a suspension bridge would be constructed to carry railway traffic—these girders, having to support neither their own weight, nor any other portion of the dead load, but simply half the maximum rolling load, will be light in comparison with the girders for an ordinary bridge of equal span. They will be sufficiently flexible to follow the rise and fall of the chains; never ceasing to be truly *suspended* girders, at the same time that they possess rigidity enough to distribute any partial load equably over the chains, and to keep the wave caused by the rolling load within moderate and safe limits.

After what has been said, it is obvious that the economy of the suspended girder is greater for a single span than for a bridge of more spans than one, since the girder in the latter must be four times as strong as that in the former. The deflection in the bridge of one span only will (as we have seen) be one-fourth of the deflection of an ordinary girder bridge of the same span and same depth of girder; while in the multiple span bridge the deflection becomes equal to that of the ordinary girder bridge. The deflection in each case has, however, to be increased by the amount of settlement due to the stretching of the chains when the maximum rolling load traverses the bridge.

On examining the expression for this settlement, which has been aready given as $\frac{25e}{32}\left(\frac{s^2}{4v}+\frac{4v}{3}\right)$, we find that it diminishes as the rise of the chains increases; reaching a minimum when the rise of the chains equals the altitude of an equilateral triangle having for its base half the span of the bridge. By giving a considerable rise to the chains we therefore effect a saving of strength, and thus of material, not simply in the chains themselves, but also in the suspended girder, by reducing the strain on the latter resulting from settlement.

It may be as well before dismissing the subject to add a word or two on the resistance offered by the chains *per se* to an irregular displacement, and the amount of error involved at the outset of this inquiry (see *ante* p. 318) in neglecting this element of stability; and considering the *form* of the reflex wave as entirely governed by the law of the girder, while its *magnitude* depends on the law of continuity of the chains. If we take the same example as before, viz., a bridge of 400 feet span, 50 feet rise of chain, and a dead load of 300 tons, inclusive of weight of chains and girder; and suppose a weight of 1 ton placed at the quarter-span; the chains over the same point would be drawn down about 1 inch, if there were no girder. But if we take the girder (of the same strength as calculated before for the single span), we shall find that it will take a weight of more than $5\frac{1}{2}$ tons at the quarter-span to cause an inch deflection, without the chains. In this case, therefore, the resistance of the chains to a small displacement would be about 18 per cent. of that of the girder, and would tend to reduce the wave calculated on the preceding principles by a like percentage. But there is also another consideration to be taken into account, operating the other way. When the rolling load comes on a bridge the added strain will cause the stay-chains to stretch, and this will occasion an increase in the deflection of the bridge. There are thus two causes, one of diminished, the other of increased disturbance, which to some extent counteract one another, and which are not reducible to a general rule, as they vary with the conditions of each bridge. Their operation therefore has to be

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specially calculated, and allowance made for them, when applying the results of general theory to any particular case.

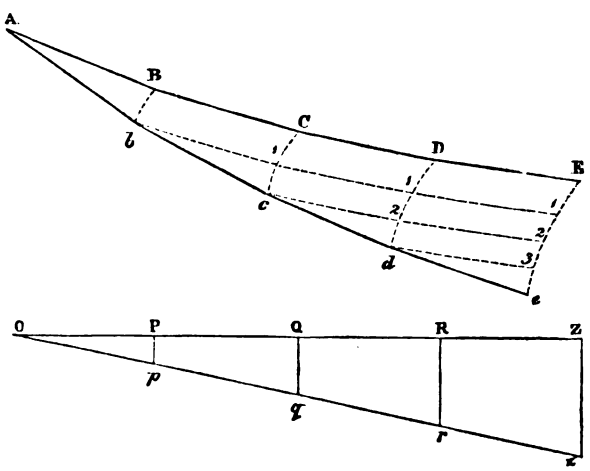
It must be borne in mind that the displacements we have been investigating are *very small*, consisting of inches, where the span consists of hundreds of feet. The resistance of the chain rapidly increases when the displacements become large enough to cause an appreciable alteration in the rate of curvature of the chain. In this respect the chain has a very different law from the girder. If a load of 50 tons deflect a girder 10 inches, we may expect a deflection of 1 inch for a load of 5 tons. Not so with the partial displacements of a chain. If 50 tons caused a displacement of 20 inches, it would by no means be a just inference that 5 tons would cause a displacement of only 2 inches. Thus, in a model in which the wave is greatly magnified, and especially when there is a large distributed dead load on the platform, the action of the chains in reducing the wave will be proportionately much greater than in the actual bridge. As we have already seen, the wave in Mr. Barlow's model is in each instance less than theory would indicate; and the more so as the stiffness of the girder is reduced, or the distributed dead load increased. The consideration just adduced furnishes a clue to this discrepancy.

While therefore the strength of the chain is sufficient to carry a load that would prove destructive to the girder, if not suspended, the resistance of the girder to small partial displacements is far more powerful than that of the chain. For the strength of the girder consists in its rigidity; whereas the equilibrium of the chain is dependent on its readily adapting itself to any particular curve required by the distribution of the rolling load at a given moment. The suspended girder, by virtue of its rigidity, transmits a partial load to the chain in the form of an equally distributed pressure. Thus the girder preserves the equilibrium of the curve of the chain, while the chain furnishes the ultimate support of the whole, or nearly the whole, of the load.

It is perhaps due to the reader to explain how we arrive at the general expression for the horizontal displacement resulting from the deflection, or the pulling up, of a chain; the more so, as it forms, in fact, the basis of the whole of the foregoing investigation. The general expression referred to is $\int \frac{dy}{dx}.dz$, given *ante* page 318.

In Fig. 1, ABCDE represents part of a chain in its original

Fig. 1.



position, and A*bcde* is the same chain after displacement; the point A is supposed to be fixed. OZ being a horizontal line, O*pqrz* is the curve of the vertical displacements of the chain, the ordinate P*p* being equal to the difference in height between B and *b*; the ordinate Q*q* to the difference in height between C and *c*, and so on. The displacements are supposed to be small, although in the diagram it is necessary to make them large, for the sake of clearness. The length of chain A*b* is equal to AB, *bc* to BC, and so on, to *e*. Each length of the chain except AB undergoes at once a change of *place* and a change of *direction*. The change of place is again resolvable into *vertical* displacement, which is already plotted in the ordinates of the curve O*z*; and *horizontal* displacement, which is what we want to determine, and which is the aggregate effect of the changes of position of the successive lengths of chain. It will assist the understanding if we distinguish between the change of place and the change of direction, by considering them as successive instead of simultaneous.

First, then, AB assumes the position A*b*. The necessary result is a change of position of the remainder of the chain BCDE to *b* 1 1 1; the points C, D, and E taking a parallel motion equal to B*b*, as indicated by the dotted lines C 1, &c., so as to produce change of place without change of direction.

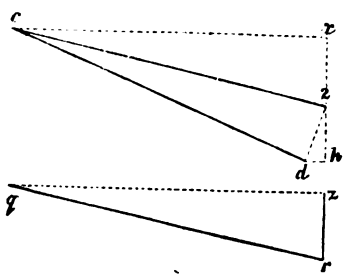
Next, let BC, after moving as we have seen to the position *b* 1, undergo its change of *direction*, assuming that of *bc*. CDE will now sustain a second change of place, viz., from 1 1 1 to *c* 2 2, the dotted lines 1 2 (indicating the path of this movement) being equal and parallel to 1 *c*.

The next step is for *c* 2 to fall into its new direction, *cd*: this will be attended by a parallel movement of 2 2 to *d* 3. Lastly, *d* 3 assumes its ultimate direction *de*.

By thus laying down the paths, E 1 2 3 *e*, D 1 2 *d*, &c. in which the various points in the chain may be supposed to travel to their new positions, it is rendered obvious that the displacement of E, both vertical and horizontal, is the sum of the effects of the changes of *direction* of the several lengths of chain. So that if we find the horizontal movements given by the change of direction of AB, BC, &c., and add them, the sum will be the amount of horizontal displacement at *e*.

Fig. 2 gives an enlarged view of a length *c* 2 of the chain, and its movement to its ultimate direction, *cd*: *qr* is a corresponding portion of the curve of deflection. *x* and *y* being the horizontal and vertical ordinates of the point *c*, as measured from some fixed centre or origin, *cx* in the diagram will be the differential of *x*, and *x*2 the differential of *y*: *rz* will be the differential of *z*, and will be equal to the element (*h*2) of vertical displacement.

Fig. 2.

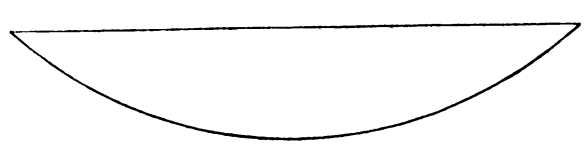


If *c* 2 *d* were a right angle, the right-angled triangles *dh* 2, 2 *xc*, would be similar to one another; but as the angle 2 *c d* is supposed to be very small indeed, the error resulting from considering *c* 2 *d* as a right angle is too small to be of any account. We may therefore regard the triangles *dh* 2, 2 *xc*, as absolutely similar. It results from their similarity that $\frac{dh}{h2} = \frac{2x}{xc}$; and therefore $dh = \frac{2x}{xc} \times h2$. That is to say, the differential of horizontal displacement (*dh*) is equal to $\frac{\text{differential of } y}{\text{differential of } x} \times$ differential of *z*

The sum of the horizontal differentials of displacement from A to E (Fig. 1) will therefore be equal to $\int \frac{dy}{dx}.dz$, between the same points; so that this expression gives—with a minute error—the actual horizontal displacement of *e*.

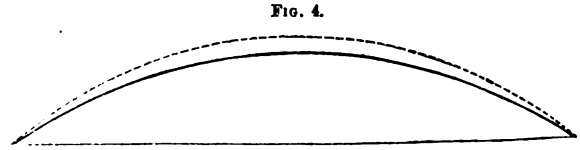
We add by way of illustration three figures, to a magnified

Fig. 3.



vertical scale. Fig. 3 is the wave of simple deflection which the girder would fall into without the support of the chains, when half the rolling load was on the bridge. In Fig. 4, the dotted

Fig. 4.



curve shows the reflex wave in which the chain (to preserve its continuity) would draw up the girder, were it not for the stretching: the full line shows the *actual* reflex wave, allowing for the stretch-

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ing. Fig. 5 exhibits the compound wave which results from the simultaneous action of the wave of deflection in Fig. 3 and the reflex wave in Fig. 4. The dotted line shows the equal rise and depression which would take place if the chains did not

Fig. 5.



stretch: the full line shows the actual result after the settlement of the chains.

We have now accomplished the object proposed in this article, by briefly indicating the steps by which an intelligible and consistent theory of the suspended girder may be arrived at; comparing its results with those obtained by Mr. Barlow from his experimental model; and pointing out those practical conclusions which seem most obvious or most important. We refrain from inquiring into the sufficiency of the girder proposed by Mr. Barlow for the multiple span bridge at Londonderry, as such inquiry would not come within our present scope. The application of the principles attempted to be laid down to the examination of this or any similar case would, however, be very readily made, provided the section of the intended girder were given. The conclusion that immediately concerns us is the practicability of the suspended girder for railway bridges of heavy spans; the marked economy, moderate deflection, and perfect safety of bridges constructed on this plan; and the proportions and other conditions to be observed. Experiment and theory have now done their part. Each involve some known, and possibly also some unsuspected, sources of error. It remains for the practical engineer, by the bold test of some actual work, at once to correct and verify the conclusions of abstract science, and remove the question for ever from the province of discussion.

FOREIGN PUBLICATIONS.

In a recent number of the *Révue* of M. César Daly we have a continuation of the plans of French railway stations, which, as we have previously had occasion to remark, it is proposed to publish in that periodical; these will not be without interest to all concerned in railway arrangement, especially as they show very clearly-marked deviations from the ordinary method of arrangement in England; deviations occasioned, it will be understood, by the entirely different system upon which French and English passenger-traffic is regulated. In France the passengers are kept, till the last moment before the departure of the trains, in separate waiting-rooms—one for each class, and they are not admitted to the platforms, as is done in England, at once on booking their places. Further, the whole of the luggage of passengers is taken charge of by the railway authorities, and tickets are given for it, by means of which it is reclaimed at the end of the journey. These arrangements, which remove from the traveller all opportunity of taking care of himself or of his luggage, necessitate the employment of more officials, and the appropriation of more space for waiting and luggage rooms than the English system, according to which the traveller has to a great extent the responsibility of looking after himself and his luggage. Those who have witnessed the hopeless obstruction of a French passenger-station on occasions of an unusual press of traffic can comprehend how unequal such a system is to cope with emergencies, though under ordinary circumstances it works well enough. It has notwithstanding been the opinion of some engineers, that this system deserves to be partially tried in England. Should such an experiment be attempted, the plans we are now referring to would show excellently well what dispositions of plan have been found requisite to its working in France.

We have some views given also of the private chapel in the Château of Touvant, the work of M. Aymar Verdier, and described by Dr. Cattois. These two gentlemen are favourably known by their joint work on Mediæval and Renaissance architecture in France, some account of which we hope to lay before our readers on a future day; and M. Verdier has just received the decoration of the Legion of Honour. The chapel is a good specimen of modern French Gothic, with some graceful and original features both of decoration and construction. In the description appended to it Dr. Cattois has taken occasion to refer to the contrast presented by the Renaissance of the sixteenth century and that of the nineteenth. The writer speaks of the works of the Mediæval revivalists in France in a tone of disappointment that we had hardly expected to meet with; and contrasts the failure which he considers has up to this time attended their efforts, with the activity and success of the old Classic Renaissance: avowing openly, that "There was no need to establish the difference between this and that other Renaissance; this one less fortunate than its predecessor, inasmuch as it has completely failed in its efforts; for all its Gothic productions have met with pretty nearly the same lot, all have deceived the expectations of the public." Again, further on,—"To what can we attribute a defeat, avowed even by those who have the most interest in at least keeping it hidden till better days? More than a quarter of a century will have been consecrated to useless, shall I say contradictory efforts, in a direction to the accomplishment of which neither zeal, study, science, nor immense sacrifices have been lacking; and yet, such has been till now the sterility of the enterprise, that its warmest partizans, moved by many of their chiefs, do not hesitate to admit, that not only has success been wanting, but that the efforts of the movement have turned against itself."

We in this country should not be disposed to make such admissions regarding our own Gothic revival, notwithstanding many of our best critics would be disposed to agree with them as applicable at least to a good deal of French Gothic work: we at the same time would heartily go along with Dr. Cattois, who (had we space to quote all his paper) would be found to acknowledge that his own country presents some brilliant exceptions to the condemnation he has passed. It will be interesting to know the reason he assigns for this failure, and see to what extent the spirit actuating the English revival has differed from that of the French one.

Dr. Cattois, with great judgment, points out that the Classic art revived in the sixteenth century had but little in common with religious enthusiasm: "Its measure, its height, and if we may so speak, its true greatness, was *man*, and it did not go beyond him; in this widely differing from Mediæval art, which exists not save on condition of being at once a moral and a scientific teaching, a manifestation of traditions and doctrines." This well-conceived idea is not worked out to the extent which its profound truth deserves in the essay from which we are quoting, and it would be out of place to pursue the discussion here; but enough has been said to enable our thoughtful readers to construct for themselves a satisfactory theory to explain how naturally, in infidel, rationalistic, antiquarian France, the study and revival of Gothic architecture should have remained a precise, geometrical, well-arranged analysis, and a subsequent construction of carefully finished works whose correctness is only equalled by their pedantic spiritlessness. That these words are not too strong to characterise much of the modern Gothic work in France we are convinced from personal knowledge.

That our own revival did not remain in the same groove is not due to those who commenced it. They started—and how else could they start?—with a long, patient, and enthusiastic examination of the remains of the past, and a laborious classification of precedents and examples. Here, unhappily, their influence has been so great, that a large body of the public, including many of the clergy, have not got beyond the trammels of antiquarian precedent. The progress which has since been made, and has placed nearly all our architects far in advance of the archæologists of thirty years ago, is due mainly—perhaps solely—to the strong religious fervour with which that party are pervaded who, both in the Church and the studio, have carried on the revival. The Mediævalists and the Pre-Raffaelites of the present day are animated by a genuine spirit of devotional enthusiasm in their cause; and their having in this particular approached the fervour of the ancient monks and architects—a circumstance which has not occurred in France—is probably the true reason of the genuine character of our best work of the present day.

We learn from the same source that in the last session of the Corps Législatif, the most laborious and fruitful since that of 1852, no fewer than 147 acts for local loans were discussed and voted: some of these loans, in the case of cities that desire to emulate the recent embellishments of Paris, amounting to millions of francs; while the city of Paris has obtained a grant of the Wood of Vincennes, on condition of expending on its embellishment the enormous sum of 130 millions of francs, also raised by loan.

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RECOLLECTIONS OF SICILY.*

By Sydney Smirke, R.A.

Whatever may have been the causes, certain it is that Sicily has been very imperfectly explored by artists and archæologists, although it is a land abundantly rich in the remains of every age of historical interest,—Phœnician, Greek, Roman, Arabian, Norman, and Mediæval. I will not dwell on the strong claims this island has on the attention of the naturalist. It is here only in Europe that we find growing wild the papyrus and the palm, productions which seem to link it with the East, and aid the remains of Saracenic art in recalling to our memories the age of the Caliphs; whilst there are not wanting traces of architecture which forcibly remind us of the times of our first Henries and Richards. So multifarious indeed is the interest with which this sequestered island is invested, that I cannot but be surprised at the slender amount of knowledge usually possessed by even the best informed artists and antiquaries on the subject of Sicily. I feel persuaded therefore that I shall be excused if I bring before your notice a condensed record of my recollections of a professional tour made in that country by me upwards of thirty years ago.

In most countries of Europe observations made from notes of so old a date would be obsolete or of little value, or perhaps wholly inapplicable to the present day; but I think I need entertain no such apprehension in this case. Until the memorable events of the last few months, Sicily has long been as it were a land of the dead for the purposes of the traveller or the student: neither its moral, political, nor physical improvement has been developed or attempted under its later dynasties, but both the place and its population have remained stagnant, neglected, overlooked, and asleep. Let me refer, for example, to that silent and dormant wilderness of antiquities which extends for miles over the site of the ancient Selinus, where, some thirty or forty years ago, two young English artists, Mr. Harris and Mr. Angell, turned up a few stones, and found on them fine specimens of archaic Greek sculpture. The attention of the sleeping antiquaries was awakened, who seemed never to have dreamt that such treasures existed beneath the dense mantle of cactus and myrtle trees that lay over the prostrate temples. Yet, when I visited those ruins a few years afterwards, this discovery appeared to have led to but trifling further researches: the upturned metopes were deposited, it is true, in the nearest museum, but were still being gazed at with barren astonishment, — they were talked about abundantly by that loquacious and inactive people, but the interesting discovery excited few efforts to explore the mine which the stranger had opened to their hands; and the listless antiquaries were again folding their arms and composing themselves for another cycle of sleep. I would by no means include in this category such authors as Hittorf and Serrodifaleo, and our own writer, Galley Knight, whose finely illustrated works are noble contributions to our art, and are ample expositions of the known remains; but even they have done little towards increasing the stores of antiquarian knowledge. The great cities of antiquity in Sicily owe their ruin, not so much to gradual decay as to external violence, such as sieges, earthquakes, and volcanic eruptions. Sudden and general *bouleversements* of this nature—overwhelming a whole city—may be reasonably expected to have caused the interment of much that is valuable to the artist and the antiquary without positively destroying it. Such proved actually to have been the case at Selinus; and it cannot be doubted that much remains throughout Sicily to reward the labours of a diligent explorer.

My course commenced at the beautiful port and city of Messina, many of whose handsome buildings I found still bearing marks of the ravages of repeated earthquakes. There is however here not much to attract the attention or invite the study of the architectural student. The cathedral is not without considerable interest, presenting as it does specimens of almost every successive style from Byzantine to Cinquecento; whilst the pillars of the nave consist of shafts derived from the ruins of some far more ancient temple; affording an example of the practice once so prevalent throughout Italy, of the adaptation of Classic relics to Christian purposes. This practice, founded on expediency, and prevalent among the builders of the early churches, is analogous to that which also prevailed in the early ages of Christianity, of attempting to reconcile Pagan doctrines and rites to the principles of Christian theology, for the purpose, it should seem, of making the work of conversion more easy for the missionary and more acceptable to the convert. Whether this was a justifiable instrument is open to doubt, but certainly it was carrying the doctrine of expediency very far when it was thought proper to dedicate churches to S. Mercurio and Sta. Venera.

In various parts of the city may be observed examples of late Gothic, somewhat purer—or, at least, somewhat more nearly allied to our own Northern Gothic—than is usually met with on the adjacent continent of Italy. I am but little acquainted with Spanish Gothic, but I am inclined to suspect that the later Gothic of Sicily will be found to resemble it in many respects. There is here an octagon tower, much shattered by earthquakes, and but little of it left to identify its age, which is traditionally reported to have been erected by our first Richard, and which bears his name. A small early Norman church which I observed at the southern extremity of the city, called La Nunziatella, is remarkable for having on its door-jambs, inlaid in coloured marble or porphyry, part of an Arabic inscription purporting to be in honour of Messala, a Saracen chief. These jambs had, no doubt, formed part of some previously existing building, which the Moslem masons, employed by their Norman conquerors, were glad of the opportunity of reinstating. It struck me at once as much resembling the ornament designated by Dr. King, in 'Munimenta Antiqua,' the "*scribbled* ornament," which may possibly be an eastern tradition testifying to the Oriental origin of some of the features of the Mediæval architecture of Europe.

Taormina is placed on a most commanding eminence, and is said to have been the last city in Sicily to yield to the Arabian invaders. Here are very interesting remains of an hypæthral theatre, a naumachia, and a reservoir for water resembling the "Piscina mirabilis" on the Neapolitan coast; its groined vaulting rests on piers of brickwork coated over with cement 2½ inches thick: there are also many tombs of Classical character. Among the ruins of the theatre I observed examples of the practice of the Roman masons of lining the surface of stone with extremely thin slabs—I might almost call them films—of coloured marble. It is a nicety, open to much question, whether this practice comes under the denunciation of shams in architecture. The block of common limestone so lined presents the appearance of marble, which it is not: it is therefore so far deceptive; yet in fact a charge of fraud seems scarcely tenable, seeing that the material used is really what it seems to be, although the quantity of the precious substance falls far short of its apparent bulk. I cannot leave Taormina without remarking how these vast and silent ruins testify to the vicissitudes to which the island has been subjected. Numerous and prosperous must have been the population of this city, when one of its places of amusement alone was capable of receiving 30,000 spectators. A few straggling dreary streets exist to mark the site of this great centre of ancient civilisation.

My next resting-place was Catania, a city which owes its modern and regular appearance to the frightful eruption and earthquake of 1693, which destroyed the old city and devastated the surrounding country, causing extensive districts to be covered with volcanic scoria, which remains to this day piled up in amorphous masses, dark and arid, relieved by few indications of vegetation, except where the cactus has found a hold for its roots in the hollows and indentations of this wide waste of cinders. Beneath the surface on which the city is built lies another bed of volcanic ashes, and within this bed lie the remains of various fine Roman buildings, including a noble amphitheatre, itself built of blocks of lava and vaulted with pumice-stone, the products of still remoter eruptions,—so persistent has been the activity of these Etnean fires. The application of volcanic scoria or pumice to the construction of the vaulting of the corridors of this amphitheatre is worthy of observation, and bears witness to the constructive ability of the Roman builders: the springings and various main ribs are executed in very sound brickwork, whilst the interstices, spandrels, and other parts of the vaulting are wholly executed with this light yet hard material, in its rough state, but run in solidly with Pozzolana cement. That this mode of construction is substantial is evident from the permanence of the work in these ancient corridors. The dome of the Pantheon at Rome is executed in the same manner, and has stood the sieges, earthquakes, and all other causes of damage and decay, for nearly two thousand years. Perhaps I may here be permitted to say that I think it worthy of inquiry whether a safe, permanent, perhaps even economical vaulting might not be simi-

* From a paper read at the Royal Institute of British Architects.

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larly executed with *coke*, a material which has many of the properties of a volcanic scoria, is extremely light, and yet so hard as to be able like the diamond to scratch glass.

Notwithstanding the labours of Prince Biscari, much remains unexplored in this amphitheatre, and still more of the adjoining odeum, which was entombed, like Herculaneum, beneath the fiery shower. Far below the present surface and beneath the modern Duomo lie the remnants of a magnificent building, used during the occupation of the Romans as public baths. Glimpses of its ornamented halls are obtainable by ascending to a considerable depth with ladders and torches into the excavated portions of the building. There are also various other Roman antiquities of less importance, but testifying to the wealth and population of this now half-deserted spot—evidence too of the deplorable want of energy and enterprise in the government and in the people, who can permit objects of so much interest and historical value to be unexplored under their very feet. A spacious and handsome Benedictine monastery is one of the most conspicuous modern buildings of Catania. It existed before the great convulsion of 1693. The museum of Prince Biscari here is well known to most European antiquaries; it is rich in fictile works and bronzes, and contains some good sculpture, including a torso of the highest character of Greek art. There is in the town also a small collection of natural history. Another similar collection is at the University; and a third, consisting of objects of natural history and of works of mechanical art, contained in four or five good-sized rooms at the monastery to which I have just alluded.

The next place of interest in my progress along the coast was Syracuse, a city of the highest historic interest, but presenting an extraordinary scene of decay and desolation. An inconsiderable seaport now, it was 2000 years ago a great centre of luxury and civilisation; the extent of which may be judged by the vast tract of country strewed with the fragments of buildings. The ride from one extremity of these heaps of ruins to the other occupies some hours, and almost every step passes over some remnant of fallen grandeur. I shall not stop to enumerate the various objects of interest here. The theatres, tombs, temples, latomie, have all been described by travellers, although by no means illustrated, or indeed examined, as carefully and thoroughly as they deserve; and there can be no doubt that an earnest, intelligent and systematic exploration of that which lies beneath this wild scene of decay, overthrow, and dilapidation, would be abundantly productive. In the ancient and entirely ruined part of the city, called Neapolis, are two ruined towns named the Epipolo, parts of the ancients fortifications of which are traceable over a great extent. Shortly previous to my visit several subterranean galleries had been discovered within these fortifications. The theory of the local antiquaries is that they had been formed as sally-ports in case of a siege. The gallery I measured was 9 feet wide, and is covered with a flat segmental arch: a fact of some interest if the workmanship could be satisfactorily proved to belong to the Greek period, which appearances, as well as the history of Syracuse, seem to favour. In the more modern part of the city, called Ortygia, are some interesting remnants of mediæval date, for the most part widely differing from the type of northern Europe. The Duomo itself is an epitome of the vicissitudes to which the city has been subjected. The side walls consist of a range of Greek Doric columns, a portion, probably, of some temple. The intercolumniations are walled up with more modern masonry. The principal front is a somewhat overloaded modern composition, whilst the ceiling within is undoubtedly Mediæval. I visited the museum here, which was small, consisting exclusively of miscellaneous antiquities found in the town and its neighbourhood. It contains a statue of Venus, life-size, found in the quarter of the ancient city called Aciadina, near the entrance into the catacombs.

I must not dwell on the Latomie, the ancient stone quarries here, though presenting scenes highly picturesque and interesting; nor on the so-called Ear of Dionysius, about which so many fantastic, though by no means plausible theories, are propounded. Nor does my time admit of my entering upon any description of the numerous tombs of undoubted Classic age; nor on the far-famed fountain of Arethusa. Somewhat removed from the city is a small church dedicated to St. Marcian, which is reputed to be one of the earliest Christian buildings in Europe. The crypt of this church, containing the sarcophagus of the saint, wears certainly an aspect of extreme antiquity. A seat in it, which is regarded with great reverence as the first episcopal throne in existence, consists of a Roman Ionic capital, inverted so as to make the volutes form, as it were, the elbows of the seat.

From Syracuse I was induced to deviate inland from the main road skirting the coast by the accounts that had reached me, from time to time, of certain remarkable excavations then in progress by the Baron Jutica on his own estates near Palarruolo, about twenty-four miles from Syracuse. Less than a mile from Palarruolo were the excavations that I sought for. The hill of Acramonte, where they are situated, is the site of the ancient city of Acræ. The Baron considered, from the evidence afforded by the remains he had himself discovered, that on this spot originally stood a Phœnician city, that it had been successively inhabited by Greeks, Romans, Christians, and Saracens. There are here remains, only in part excavated, of a theatre and an odeum; the former similar to that at Syracuse but smaller. There is also a naumachia, an amphitheatre, a forum, various temples, and numerous tombs. These multifarious ruins lie like geological strata, successively superimposed on each other. The lowest excavation, about 30 feet below the general surface, presents remains of what the Baron pronounced to be a kind of barracks, with a prison attached. There are fifteen rooms leading into each other, and in one of these rooms is a shaft leading down into some deeper and still unexplored recesses. Several pits also have been discovered, into which various horizontal subterranean passages lead from the outer surface of the hill. The purpose of these singular excavations is not obvious; the Baron's opinion seemed to be that they were intended as vents for dangerous vapours pent up within the bowels of the earth in this volcanic district. There is indeed an extinct volcano at no great distance from this spot. Some remarkable basreliefs are cut on the face of the rock, at or near the foot of this hill of Acramonte. These Santoni, as they are locally called, are of very archaic and almost Persepolitan character; but my view was too hasty and too superficial to admit of my forming any opinion as to their precise age. Baron Jutica's museum was rich in bronze and terra-cottas; some bearing Phœnician characters, others of decidedly Greek workmanship; others again Roman. These articles are as various in their nature as may be supposed, seeing that they are derived from the reliquiæ of a great city. Many glass vessels were found of undisputed Phœnician workmanship; some of opaque glass, others coloured their whole substance. Among many other curious objects was an armlet of iron plated with silver.

I proceeded afterwards to explore a remarkable necropolis at Ipsica, about five miles from Acramonte. It lies in a rocky valley, and consists of a multitude of caverns cut in the face of the rock, which being stratified in regular horizontal beds, offers great facilities for such excavations. Many of these caverns are catacombs lined with tombs, on some of which early Christian inscriptions in Greek characters are still traceable. There are, however, many caverns without any indication of interments having been made, and I found that the prevalent not improbable belief on the spot is that this valley presents the remains of a troglodite city, occupied by the earliest, perhaps Celtic, inhabitants of the island, and that it had been in after times applied to the purposes of sepulture. It is worthy of remark, as perhaps confirmatory of this local opinion, that at Modica, a town scarcely a day's journey off, there are many separate habitations and even streets formed exactly as these caverns at Ipsica are formed, by excavating the face of a cliff or rather the escarpment of a stratified rock. I should however state as regards this valley of Ipsica, the decided opinion of the Baron was that the caves had been originally excavated by the early Christian population expressly for burial; that it was in fact a great Christian necropolis. It seems to me not improbable that these rocks may have been excavated and dwelt in by the earliest occupants of the island, and that long afterwards the deserted caves may have been regarded as a fitting resting-place for the bones of the earliest Christians. Nothing indeed can well be imagined more secluded and desolate than this rocky valley; well illustrating the difference of feeling on the subject of sepulture between the Christians and the Pagans, who were wont to parade their tombs along the highways and the roadside.

From Commossa to Terranuova, and thence by Palma, I reached Girgenti, adjacent to the ruins of Agrigentum. I will not dwell on these highly interesting ruins, for they have had a fair share of the attention of the architectural and antiquarian

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world. Wilkins has illustrated some of them; Hittorf and Serrodifaleo have published careful illustrations of them; and I need not remind you that our accomplished president gave much attention to them.

The temples which are specially referred to in my own notes are those of Juno Lucina, of Hercules, of Concord, of Jupiter Olympus, of Æsculapius, of Proserpina, and of Castor and Pollux. At least, such are the deities to whom these ruins have been assigned by the local antiquaries. Most of the buildings present but a confused mass of mutilated blocks and fragments piled together; this is especially the case with the Temple of Hercules and that of Castor and Pollux; so confused a heap have they become, that it is impossible to define their plan on a mere superficial inspection. Some of the blocks thus piled together are of colossal dimensions. Even at the small Temple of Proserpina I measured a block 8 ft. 6 in. by 3 ft. 10½ in., by 2 ft. 10 in., weighing therefore five or six tons. Indeed, there are when viewing these stupenduous ruins, few things that excite more surprise in the mind of the architectural observer than the wonderful solidity of the mode of building practised by these Greeks. It is not flattering to contemplate the wide difference of practice in this respect between the builders of the sixth century before and the nineteenth century after the Christian era. It was a saying of Plato, as reported by Ælian, "that the people of Agrigentum built as if they were to live for ever, and feasted as if they were always about to die." Ælian goes on to say that "Timæus reports that they use oil-flasks and strigils of silver, and had entire couches of ivory." It should not however be overlooked that the contrast between the domestic architecture of the Greeks and that of our present generation would probably have gone far to redress the balance, if the Greeks had left behind them any adequate means of comparison. The temples of Juno and Concord are the least mutilated, and in their ruin present most beautiful and picturesque objects.

The Temple of Jupiter is the most remarkable both for its magnificent size, with the flutes of its columns 14 inches wide, and for the singular example it offers of the use of caryatides in interior temple architecture. These caryatides were built up in courses like columns, and are about 25 feet high, and 6 feet across the hips. One was lying on its back, having at the period of my visit been recently put together by Signor Politi. There had been then found portions of nine other similiar statues. An idea of the huge proportions of this temple may be gathered from the fact that the diameter of the columns of the peristyle is considerably, more than half as great as that of the Monument in London.

Little need be said of the modern town of Girgenti: it is built very irregularly, but is of some extent, and is not without some signs of a certain degree of prosperity. There is an extensive ecclesiastical seminary, and a cathedral. The latter is a modern structure, remarkable for a *porta-voce*, which it is usual to point out to the notice of strangers. Although the building is of great length, a low whisper at the west door is said to be distinctly audible behind the altar at the eastern end, and that notwithstanding the intervention of a transept. The nave consists of a Doric colonnade with a continuous unbroken entablature—a circumstance no doubt favourable to the conveyance of sound. The baptismal font is remarkable, being an ancient sarcophagus, of Classic workmanship, applied to this very different purpose. The sides are sculptured with figures about three feet high, the subjects being taken from Phœdra and Hyppolitus. Many doors and windows and other details, of Norman architecture, are met with in the town of Girgenti, in which the chevron ornament is profusely used,—a peculiarity the more noticeable from the general absence of that ornament in Italy, contributing therefore to strengthen the presumption that the Norman adventurers brought their arts as well as their arms to this island.

At Sciacca, a large rambling town, wearing an aspect of much poverty, the only architectural object was a convent of nuns, outside the eastern gate, which was a large and striking building of perfectly Mediæval character, and, as far as could be judged from the exterior, but little modernised. The impossibility of gaining admission of course increased my desire to enter: a visit to the interior would doubtless have been as it were to step back at once into the middle ages.

Castel Vitiano, an ancient town, at no great distance from the ruins of Selinunte, is now only a dreary waste of mutilated masonry; in fact, even more entirely ruined than Agrigentum. It appears to have been built upon two low hills close to the sea-side. Little of all this vast tract of ruin is now traceable, except some of the external walls, and portions of some temples. Whilst wandering over these relics of a wealthy and active population long since passed away, I met with a well, of undoubted antiquity and of peculiar construction, being lined with cylinders of terra-cotta, still in excellent preservation. This Greek mode of forming a well appears to me to be on a sounder, more sensible, and more workmanlike principle of construction than the modern mode of steining wells with bricks or small stones. The internal diameter of these cylinders is 2 ft. 1 in., the uppermost cylinder being a trifle larger; the thickness of the sides is about 1 inch, and their ends are thickened to 1½ inch, for the purpose of increasing their strength and giving them a better bearing on each other. The durability of this mode of construction is proved satisfactorily enough by the present perfect condition of this example; and that it would exclude impure and superficial springs better than the ordinary brick steining must be obvious.

Adjacent to the ruins of the city are the remnants of three fine Doric temples. That which is the farthest from the sea is of magnificent dimensions, very little smaller than the great temple at Agrigentum. These temples have been already made familiar to most of us by various published illustrations. Their style is somewhat heavy and archaic. The metopes found here by Messrs. Angell and Harris are well known to all of us, casts being in our great national Museum. These bas-reliefs are carved in a limestone, quarried at the Latomia of Campo Bello, seven or eight miles distant, which appears to have supplied materials for much of the architecture of the ancient city; although many fragments of statuary marble are to be found scattered about. At this quarry, which I did not fail to visit, I observed the mode adopted of getting out the cylindrical blocks or drums for the shafts of the columns. They appear to have been cut or scappled out *in situ* from the living rock, the cylindrical blocks being worked out to nearly their true size and form by forming a channel or interval all round, so as to render them insulated, though still undetached, from the living rock. The length of each block was of course regulated by the depth of the cutting around it, or rather, perhaps by the depth of the vertical face of the rock at its escarpment. In some cases I found these drums 10 feet high. By what process they were detached and lifted from the parent rock does not appear, from any indication that I could discover. Many of these portions of great Doric columns remain in various stages of completion at the quarry, just where they have lain undisturbed ever since the overthrow of the Selinuntines in 409 B.C. What a picture of retrogression do these appearances present! When the world was not much more than half as old as it is now, there existed here a quiet, rich, and even civilised population. That the people were vigorous and energetic we see plainly by their works; that they were highly civilised we may infer from the character of their art: yet now the silence of desolation prevails amidst a scanty and degenerate people, who allow all these remnants of their ancient greatness to lie unheeded.

At Marsala I examined the cathedral, which is of modern style, but ancient ornamentation. The marble pillars are said (I know not with what truth) to have been originally intended as a present or oblation to the chapel of St. Thomas à Becket at Canterbury.

The ancient city of Segesta, except the striking and beautiful remains of the one well-known temple, and part of the external walls of an amphitheatre, presents an undistinguishable mass of mutilated fragments of worked stone, covering a very extensive area, and baffling all attempts at defining any separate building. Never was there a picture of more complete destruction; but it cannot be doubted that an explorer, having abundant leisure and energy, might reap here a rich harvest, were he to proceed methodically to lay open the contents of the piles of worked stones that have been lying undisturbed for so many centuries. I will not enter from my note-book any description of the temple here. Justice has been done to it by Serrodifaleo and others. I would however remark that there are various unmistakable evidences of the building never having been completed: its progress, we may presume, was arrested by the utter and final discomfiture of Segesta by the Carthaginians. There are rough bosses projecting from the face of the stones of the plinth, left there no doubt to facilitate the hoisting and setting of the stones, and intended to be subsequently worked off. The shafts of the columns also are unfluted, the surface appearing to be left for the

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flutes to be worked afterwards. We may infer from these indications that the practice of the Greek masons was to finish their work in detail when up, and subsequently to the erection of the building. Were this practised more frequently by ourselves we should both save expense and gain effect, for it is impossible to prevent a mason from over-labouring his work when done on the bunker. But our workmen are too apt to be opinionated and intractable, and influenced by routine and prescription.

Palermo is situated in a beautiful bay, and surrounded by the richest country and perhaps the loveliest wooded hills I have ever seen. No traces remain here, as far as I know, of the more ancient inhabitants of this island, but that it was the favourite resort successively of the Saracen and Norman masters of the country is abundantly testified by a variety of existing remains. The cathedral is remarkable for a diversity of styles, with a modern dome, a florid Gothic porch, the rest of the exterior for the most part Norman—such at least is the term which comes nearest to its correct designation, for it was built during the Norman rule, although it is a Norman widely differing from that of the north of Europe. This deviation is probably due to the strong infusion of Saracenic workmanship, which it is easy to account for. The Norman ecclesiastics, no doubt, would bring their knowledge of architecture to bear upon whatever churches they may have caused to be built when the island fell under the dominion of their race; and the plans of their churches were strictly Norman; but the actual carrying out of the work must have necessarily been intrusted for the most part to the Saracenic natives, who were excellent masons, and belonged to a far more æsthetic faith than the rude crusaders from the North. It was natural, then, that much of the ornamentation, and many of the leading forms, should savour of Eastern art, both Byzantine and Arabian. The Royal Chapel, the Church of St. Martorana, and the Cathedral at Morreale, a few miles distant from the city, are, as regards their earliest portions, interesting examples of this modification of Norman architecture, and are in their style generally similar. The walls and other flat surfaces are incrusted with inlaid marbles; their vaultings, spandrels, and soffits, as well as portions of their walls, covered with mosaics of Byzantine workmanship, as is apparent from the Greek costumes prevalent throughout. These arches are pointed, without mouldings or splays, and for the most part they rest on ancient marble shafts, no doubt derived from Classical buildings, with capitals often imitating in a rude way the Roman work.

The subject of Saracenic art in Sicily is not yet in a very satisfactory position. Since a paper in vol. xxi. of the 'Archæologia,' —written by myself when but a tyro in the archæology of our art, and before the existing examples had been critically examined by travellers—various writers have treated on the subject, who have not in all cases had any personal knowledge of the buildings themselves. There can be no doubt with respect to the churches I have named that they are of Christian, and therefore Norman origin, dating from the early to the later part of the twelfth century. But there are two secular buildings, the Zira and the Kooba, that belong to a very different category. That they were the palaces of the Saracen Emirs before the invasion of the Normans, there are, I think, the strongest possible grounds to believe. The fountains and alcoves, the interior courtyards, the numerous Cuphic inscriptions, all savour of Oriental taste and art, and are identical with the domestic architecture of the neighbouring Asiatic continent. The very name of the Zira may be identified with the name of a Caliph of the tenth century; and as to the Kooba, that is a Saracen word, equivalent to a cupola, a covering, a tent; and there are said to be koobas all over the Moslem world.

Roger, the first Norman king, in an existing diploma, speaks with regret of the marvellous palaces (*Palatiorum suorum studio mirabile compositorum*) of the Arabs which had been pitilessly destroyed by the conquerors; and there can be little doubt that during the two centuries of their undisturbed rule in Sicily the luxurious Arabs erected many such *maisons de plaisance*. As such they are stated by Smyth to be specially referred to in an Arabic MS. preserved in the library at Morreale. As the residences of the Emirs these palaces are referred to by other early Sicilian historians, quoted by Farello in the sixteenth century. Alberti, a little later, so treats them; more recently D'Agincourt so regards them; while Hittorf and Gally Knight do not hesitate to point them out as examples of Saracen art of the tenth century. It is true, a certain Benjamin, who visited Palermo in 1173, speaks of the Zira as one of the marvels of that city built by William; but as Gerault de Prangeg, one of the latest authorities on the subject, truly says, it was a common practice in the middle ages to speak of one who had but repaired or even greatly embellished a church or monastery as the builder of it. M. de Prangeg is an eminent authority on such a subject, and he has evidently referred to these two Sicilian examples with great care and caution. He admits the absence of direct proof, but he clearly leans to a belief in the pre-Norman and Saracenic origin of at least one of them, the Zira.

On the whole, I may say that the force of evidence satisfies my mind that these buildings, which in their exterior are identically alike in style, were originally built during the rule of the Saracens; that they went to decay during the strife with the Normans; and that they were ultimately renovated by and adapted to the use of the Norman conquerors, when those interior works were done which so closely resemble the Siculo-Norman portions of the churches to which I have adverted. The beauty of their situation could with difficulty be paralleled; and such indeed appears to have been the opinion of the builder, for, inscribed in large Cuphic characters along the parapet of the Kooba, are words which are stated by Smyth to have been translated thus:—"Europe is the glory of the world; Italy of Europe; Sicily of Italy; and the adjacent grounds are the pride of Sicily."

Lying among the wooded hills to the east of the city is the Benedictine monastery of St. Martino, a magnificent modern structure of great beauty: the library especially is large and handsome, and the principal staircase, rich in polished marbles and alabaster, is one of the most striking features of this very noble building. Perhaps a less indulgent critic, in the interest of morals rather than of æsthetics, might suggest the incongruity of this ostentatious display of art and decorative luxury in a building dedicated, not so much to the service of God, as to the domestic uses of a religious community professing a rule of self-denial and an abnegation of all personal enjoyments. It seems probable that to secular pride, and a spirit of rivalry with some neighbouring ecclesiastical establishment, we are indebted for many such great works in connection with the Church and its various orders and endowments. A showy picture in the hall of this building represents a colossal St. Martin mounted on a prancing charger, and cutting off the skirts of his crimson cloak for the benefit of a prostrate beggar, not without a certain air of swaggering and vainglory.

About three miles north of Palermo is La Favorita, a royal residence of most fantastic character, both gardens and palace being strictly Chinese. I need not dwell on this elaborate toy, but cannot refrain from noting, that so anxious did the royal occupant appear to be to disencumber himself from the restraint imposed upon him by the presence of servants, that his dining-table was contrived so that the dishes and plates should rise and descend through apertures in the floor; thus, when a fresh course had to be served, a bell was rung, the dishes disappeared downwards, and after a short delay rose again from below with their varied burden of fresh delicacies. Other whimsical arrangements I noted which need not be mentioned here.

About eight miles south of Palermo is La Bagharia, a village where many of the Palermitan nobility have their pleasure houses. That of Palagonia is a remarkable specimen of the grotesque. The quantity of marble sculptured into deformed figures, uncouth animals, and shapes that defy all natural classification, is almost beyond conception. The ceilings of the principal rooms are of looking-glass, and the same material lines also the walls, together with polished marbles, agates, and jaspers. As a specimen of the affectation, not very uncommon in Italy, of attempting to make their furniture the vehicle of a sentiment, the following inscription appears on one of the walls of this palace:

> "Specchiati in quei crystalli e nell' istessa
> Magnificenza singolar', contempla
> Di palazza mortal l'imago espressa."

In the library I took note of an easy chair which was readily convertible into a short flight of steps for reaching the upper shelves; a contrivance which I have occasionally since seen attempted nearer home, but never, I think, so successfully as in this piece of Palermitan joinery.

At the villa of Prince Butero the chief curiosity was a large building in the gardens, called La Certosa, being in fact a counterfeit convent, with its separate cells arranged exactly after the manner of such establishments, these cells containing monks of waxwork, worthy of the *atélier* of Madame Tussaud, and each cell

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provided with bed, seat, table, cooking apparatus, books, &c. I never happen to have seen before a baby-house on so colossal a scale. I have some recollection, too, of waxen representations of nuns as well as monks, occupying these cells in most uncanonical companionship; but so preposterous a *divertissement* for the amusement of the princely owner of a country-house seems incredible if I had not found it duly recorded in my note-book. Another curiosity, but of a very different character, is the burial-place of a Capuchin convent, near Palermo. It consists of various galleries of considerable extent; there are twenty-five small chambers leading out of these galleries, into which bodies are placed on their first arrival, and where they remain six months shut up for desiccation by heat. When thus prepared, the bodies are brought out like dried mummies, and clothed in their ordinary costume during life—priests in their canonicals, monks in the habit proper to their order, and so on. The shocking-looking objects so dressed up are then placed in a standing posture, each in its niche. Nothing possibly can exceed the hideous deformity of the spectacle presented by the avenue of niches so tenanted on either side of you as you pass along the galleries. Each body is held up in its place by a cord round the waist, attached to the back of the niche. But this cord by no means always suffices to support them in an upright position, the ligaments of the limbs gradually yield to the weight of the body, which consequently falls or rather stoops forward, and is prevented from falling down only by the cord; the ghastly head droops downwards or sideways, the dark brown countenance looking truly frightful; the arms, too, droop, and the legs give way under the weight they are no longer fit to support. Under each niche are written the name, age, and period of death of the individual it contains. The miserable remnants of mortality thus exhibited present a combination of the ghastly and the ludicrous which I suppose could hardly be equalled. Certainly the bad taste of the exhibition may well be supposed to be without a parallel, unless indeed it be found in Rome, where at the cemetery of a Capuchin convent near the Barberini Palace, are vaults containing niches tenanted by the bodies of the dead brethren preserved with the skins on, and clothed in their ordinary dress. The roofs of these vaults are ornamented with human bones formed into panels and pateras, and are lighted by lamps shaped out of the bones of arms and legs, symmetrically arranged and adapted to their new posthumous use.

I have now cursorily touched upon some of the chief objects of interest or curiosity that attracted my attention. Although my stay in the island extended over two months, and my whole time was spent in constant activity, I felt regret at leaving its shores, for my visit had been one of the highest interest. My regrets were further enhanced by the conviction I felt that much remained unseen. The coast road from Palermo to Messina remained unvisited, including Cefalu, Tyndaris, and Termini, where, besides what has already been made known, I cannot doubt but that there is much of antiquarian interest at least to reward the researches of future explorers. But reports reached me of some thirty *fiumi* that had to be crossed, and of the almost total absence of bridges over them. These *fiumi*, be it remembered, although dry ravines in the summer, are very formidable torrents during the two or three wet months of the year.

As to the interior of the island, all accounts agreed in describing it as devoid of architectural interest, few buildings of the best periods having survived, it is said, the ravages of the frequent earthquakes with which this beautiful island has been for so many centuries afflicted. I was still further deterred by the reported absence of roads and inns; evils for which not nature but man alone is answerable. Still, I have always regretted that I did not make any exploration inwards, and I strongly recommend those whom the altered circumstances of the country may induce to visit Sicily to traverse its little-known central districts, where I feel convinced there is a rich harvest still unreaped. Such a student would do well to provide himself with a sound and correct knowledge of the early history of this remarkable country, and of the races which have successively and even simultaneously occupied it. He will find traces more or less distinct of at least eight populations—namely, Celtic, Greek, Punic, Roman, Ostragothic, Arab, Norman, and Italian. Perhaps no country of like extent in the world has derived its population from so great a variety of sources.

But if antiquarian and artistic wealth lies concealed in this shattered island, how infinitely richer are the unhidden and unheeded sources of physical wealth! Although the cultivation of the soil is most primitive and imperfect, and although the nature of the tenure on which land is usually held there is most adverse to agricultural improvement, yet it is still a land abundant with corn, wine, and oil. Capt. Smyth, who knew this country intimately, pronounces it to be "one of the most fertile spots on earth." Untold wealth in flax, timber, sulphur, marble, and no doubt very many other natural products, only wait the capitalist and merchant. Of the article I have last named, only the white veined marble finds its way into this country, yet various coloured marbles and jaspers of great beauty are produced, and were, we know, duly appreciated by the architects of ancient Rome in its best days. The following may be named as the localities of some of them, as furnished to me by an intelligent mason at Palermo:—Marble di Trapani, of a grey colour; Marble di Castelnuovo, of a yellow colour; Marble di Segesta, of a yellow colour; Marble di Taormina, of a red colour; Marble di Parco, of a yellow colour; Marble d'Ogliastro, of a red colour; Marble di Castellaccio, of a grey colour. The two last-named marbles are readily obtainable in blocks 12 or 13 feet long. Specimens of some, if not all of these, I found included in the fine collection of polished marbles made by the learned and amiable Avocato Corsi, of Rome, which collection was subsequently brought to England, and exists now, I believe, at Liverpool. Each specimen it contained is not less than 8 Italian inches long by 4 inches, and 2 inches thick, and is highly polished. It comprises ten varieties of agates, a mineral in which Sicily is so rich that one of its rivers, the Achates, is supposed to have given to it its name. There are also at least eighteen varieties of jasper, in which beautiful substance Sicily is stated by Corsi to be more abundant than any other known locality. A recent writer has stated that there are no less than fifty-four varieties of Sicilian jasper. That a trade has not been established in these precious productions can only be due to the want of enterprise and capital in the island, a want easily accounted for by the long-continued course of wretched and degraded misgovernment.

What may we not hope for from the country when it shall have firmly established its political freedom, and re-entered upon the path which freemen alone are destined to tread! The present apathy, indolence, and ignorance of the people will, it is to be feared, oppose many and heavy obstacles to the re-establishment of a durable and prosperous administration. But such was not always the character of the Sicilians. When, in early times, Palermo was besieged, the patriot women are said to have given up the hair of their heads to serve as the bowstrings of their gallant defenders. May we not then reasonably hope that in the counsels of Providence it may be permitted to this ancient people to vindicate for themselves some portion of that moral and material eminence which their forefathers of old so worthily achieved?

THEORY OF GIFFARD'S INJECTOR.

Among the novel contrivances recently brought under the notice of engineers, not one has received so much attention from the mechanical world as Giffard's new Injector for feeding steam boilers. In a previous number of our Journal we gave a description (with illustrations) of this interesting apparatus, without however offering any remarks respecting its theory. Dr. Zeuner, professor of the Polytechnic College, Zurich, has lately investigated theoretically this subject, and found his researches confirmed by a series of experiments recently made on this feeding apparatus by M. Villiers, at St. Etienne, France. In order to understand more fully Dr. Zeuner's theory (of which we shall presently give an account translated from our contemporary *Der Civilingenieur*,) we first submit to our readers a summary of these experiments.

The instrument on which the following experiments were undertaken was substituted for a feeding-pump, or so-called donkey-engine, of two horse-power, which had to maintain the supply of water to four boilers, each of 4 ft. 4 in. diameter, and 50 feet length. The conical opening admitting the steam into the chamber (see description of Giffard's injector, *ante* page 268,) was 0·475 of an inch, and the orifice receiving the jet 0·35 inch in diameter. The position of the instrument was the following:—

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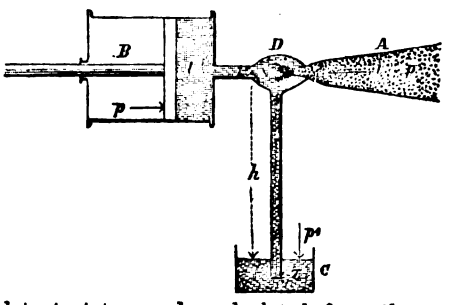
Difference in level between the float in the boiler	none.
" " " between the highest water level of the reservoir	9·02 feet.
" " " between the lowest level of ditto	14·76 "
Length of suction-pipe	19·68 "
" discharge-pipe	49·20 "
" steam-pipe	49·20 "
Inner diameter of suction-pipe	1⅛ inches.
" " discharge-pipe (feeding pipe) ...	2 "
" " steam-pipe...	2 "

The vessel from which the feed-water was absorbed was exactly measured between two distinct marks, and contained a float which was divided into small fractions of an inch, so that the reduction of water which took place could be read off to $\frac{1}{50}$ part of a pound. In order to measure the temperature of the water a thermometer was attached to the pipe leading from the reservoir to the injector; a pressure gauge was also connected to the inlet, and another to the discharge pipe, to measure the pressure of the fluids passing through them. The following table contains the results observed in the course of the experiments:—

Pressure of steam in atmospheres.	Temperature of steam (Fahr.)	Units of heat in 1 lb. of steam.	Temperature of water absorbed from reservoir.	Temperature of the discharged water.	Highest practicable temperature of absorbed water.	Maximum height of suction for starting the Injector to work.	Maximum height of suction while working.	Maximum quantity of water discharged per pound of steam.	Maximum counter-pressure in feed-pipe.	Velocity of maximum performance of steam and admixed water in the mouth-piece.	Velocity of maximum performance of water at its entrance into the discharge pipe.	Height of suction during experiment.	Velocity of steam into mouth-piece according to Combes's theory.	Velocity of discharge of steam.
						feet								
2·00	250·79	1157·14	100·4	149	109·4	4·59	11·48	9·739	2·15	59·69	37·29	9·184	62·32	1400·5
2·50	263·93	1160·94	101·75	154·4	111·2	6·56	13·12	8·969	2·75	71·67	42·64	9·184	74·13	1541·6
3·00	275·00	1164·34	100·4	158	113·0	8·03	14·76	8·154	3·40	82·33	49·20	9·840	86·10	1643·3
3·50	284·63	1167·38	103·55	166·1	113·0	9·18	15·58	7·474	4·00	93·31	57·07	9·840	98·40	1718·7
4·00	293·0	1169·91	107·6	176·0	114·8	9·84	16·40	6·795	4·75	104·14	65·93	10·168	110·21	1771·2
4·50	300·47	1172·22	107·15	181·4	114·8	10·168	16·40	6·251	5·35	114·14	73·96	10·168	122·18	1804·0

To ascertain the quantity of heat which had been turned to useful account, 1870 lb. of water were accurately weighed and absorbed at a temperature of 74·3° Fahrenheit. The temperature of the discharged water, which was conducted to an empty boiler, amounted to 140·9°, and its weight to 1995·5 lb. The pressure of the steam amounted to 4¼ atmospheres, and in order to produce the same counterpressure, and to place the apparatus in a condition as if it were feeding a boiler, the valve was so much closed that the pressure gauge attached to the discharge or feeding pipe indicated also a pressure of 4¼ atmospheres.

To judge now more exactly of the performance of this injector we return to the theory of Dr. Zeuner, who has investigated these experiments according to the principles of mechanical heat in the following manner. The quantity of heat reclaimed



from the latent state can be calculated from the quantity of steam m being converted into water of the temperature t_1, and from the temperature of the admixed water (M—m lb.), which falls from t to t_1 degrees. Assuming the steam were at first converted into water of the same temperature, that is of the temperature t, the heat rendered sensible would be $m\rho$, where ρ denotes the *inner latent heat*,* that is that quantiy which is contained in one pound of steam of the temperature t, in addition to that of water of the same temperature. The temperature of this water is, while entering the cylinder, still further reduced from t to t_1 degrees, and gives out accordingly an additional sensible heat of $mc(t-t_1)$, c being the specific heat of the water; in the same manner the temperature of the admixed water falls from t to t_1, corresponding to a sensible heat of $(M-m)\,c\,(t-t_1)$. Hence we have for the total heat rendered sensible:

$$W = mc_1+mc(t-t_1)+(M-m)c(t-t_1);$$

or rather,

$$W = m\rho+Mc(t-t_1) \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

This quantity of heat has effected the following:—

1. The amount of water Q has been raised to the height h, the requisite work to perform which was Qh; but as the pressure of the atmosphere amounts already to p_0 per square inch, there remains only for the total work required $Q(h-p_0w)$, if w represents the volume of the unit of weight (1 lb.) of water: to this effect corresponds—A being the equivalent of the unit of work—the heat

$$AQ\,(h-p_0w). \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

2. During the process the temperature of the Q lb. of water has been raised from τ to t_1; the requisite heat for this is

$$Qc\,(t_1-\tau) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

3. Finally: the piston in the cylinder B was pushed back with a constant pressure. The weight of the total quantity of water forced into the cylinder B amounted to M+Q; its volume is therefore $(M+Q)w$; and the effort necessary to accomplish this is accordingly $(M+Q)wp$. To this work corresponds the quantity of heat of

$$A\,(M+Q)\,wp. \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Adding the values (2), (3), and (4) together, we have the total heat *absorbed*,

$$AQ\,(h-p_0w)+Qc(t_1-\tau)+A(M+Q)pw.$$

This quantity of heat must evidently be equal to the heat rendered sensible and determined by equation (1). Putting these magnitudes therefore into an equation, we obtain, after a simple reduction,

$$m\rho+M\,[c(t-t_1)-Apw] = Q\,[c(t_1-\tau)+A(h+(p-p_0)w] \ldots (I.)$$

It is from this formula that the whole process may be tested. In order however to prove its correctness by the experiments referred to in the commencement of this article, it may be well to transform it a little. If the quantity of water mechanically carried away with the steam from the boiler be κM, the total quantity of steam and water is $M=m+\kappa M$, therefore

$$m=(1-\kappa)M.$$

This value substituted in equation (1) gives

$$M[(1-\kappa)\rho+c(t-t_1)-Apw] = Q\big(c(t_1-\tau)+A\,[h+(p-p_0)w]\big)\ldots(II.)$$

Let us now examine this formula. The results of the trial gave

$Q = 1870$ lb.
$t_1 = 140{\cdot}9$ degrees, and $\tau = 74{\cdot}3$ degrees.
$h = 13{\cdot}12$ feet.

Further, the pressure of the steam was 4¼ atmospheres, therefore is

$p = 4\frac{1}{4} \,.\, 22776$ lb.

The corresponding temperature to this pressure is

$t = 295{\cdot}16$ degrees;

and, according to my formula,

$\rho = 1067{\cdot}41-0{\cdot}7882\,t$;

that is, the inner latent heat is therefore $\rho = 859{\cdot}64$ degrees.

* Dr. Zeuner calls this quantity (ρ) of heat the *inner latent heat*, in contradistinction to that heat ordinarily denominated latent heat (the heat absorbed during vaporisation, but not measurable by the thermometer), and to indicate that this quantity was entirely consumed for *maintaining equilibrium* during formation of steam under constant pressure.

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Further is $p_0=22776$, $w=27{\cdot}64$ cubic inches, and $A=\frac{1}{730713}$ the specific heat of the water under constant pressure is $c=1{\cdot}0224$.

By a special experiment it was ascertained that $3\frac{1}{2}$ per cent. of water were mechanically carried away from the boiler with the steam, which gives $\kappa=0{\cdot}035$.

Instituting these values in equation (II.) we eliminate $M=0{\cdot}071Q$, and because $Q=1870$ lb. we have for $M=132{\cdot}9$ lb.; the total quantity of water therefore which would finally have accumulated in the cylinder B would be 2002·9 lb. In the experiment this quantity amounted to 1995·5 lb.,—a little less than than that derived by calculation. The difference may be attributed to the circumstance that the amount of water admixed with the steam from the boiler was in the instance of the experiment wrongly or not exactly determined; for assuming that there be no admixture of water with the steam, we should have for $\kappa=0$, in which case equation (II.) would give in a similar manner $M=0{\cdot}069\,Q$. or for $Q=1870$: $M=129{\cdot}15$ lb.; the quantity of water therefore finally contained by the cylinder must be

$$M+Q=1999{\cdot}15 \text{ lb.}$$

which is more approximate to the value in the experiment. The approximation becomes still more close if we put on the right side in equation (II.) for the specific heat of the water $c=1$, which would be even more correct, as the temperatures t_1 and τ are much below 212°, and the value $c=1{\cdot}0224$ should only be adopted for temperatures above 212°.

It is moreover to be observed, that the values of Apw and $A[h+(p-p_0)w]$ prove themselves to be always so very small, that they may be entirely neglected. The following equation would therefore be sufficient for all practical purposes:—

$$M[(1-\kappa)\rho+c(t-t_1)]=Qc(t-\tau) \ldots \quad \ldots \quad \text{(III.)}$$

Performing the above calculations according to this formula, but taking the specific heat of the water $c=1$, we obtain

$\kappa=0{\cdot}035$	$M+Q=2003{\cdot}65$ lb.
$\kappa=0$	$M+Q=1999{\cdot}9$ lb.

values which agree still better with the results of the experiment, and which would also have been obtained above in equation (II.) if c had been taken as equal to 1. At all events, the quantity of water which the steam shall have mechanically abstracted from the boiler has been stated too great; it being moreover difficult to determine the same exactly by ordinary means.

It may be observed that the formula (III.) is rendered much more simple in the case where the boiler itself is fed by the contrivance than in the instance before us, where the discharged water is supposed to be collected in a separate vessel. In such case the cylinder B is represented by the boiler, and the temperatures t_1 and t are equal: it is therefore, according to equation (III.),

$$M(1-\kappa)\rho=Qc(t-\tau);$$

or, neglecting the water mechanically admixed with the steam,

$$M=\frac{c(t-\tau)}{\rho}\,.\,Q \quad \ldots \quad \ldots \quad \ldots \quad \text{(IV.)}$$

If therefore Q is the quantity of feed-water introduced into the boiler through the apparatus, M will give the quantity of steam converted for this purpose into water of equal temperature, and is consequently lost for the use of the engine.

Putting $c=1{\cdot}0224$, and the mean temperature of the feed-water $\tau=68°$, we can compute the following table:—

Pressure of steam in atmospheres ...	2	4	6	8	10
Values of $\frac{M}{Q}$	0·224	0·275	0·316	0·350	0·379

From this it will be perceived that Giffard's contrivance for feeding boilers consumes a considerable amount of steam, which consumption will increase with the proportionate pressure in the boiler.

ON THE USE OF GRANITE.*

By Sir Gardner Wilkinson, F.R.S.

As the question of using granite for building and monumental purposes has been much discussed, I beg to offer a few remarks connected with it, and to notice a fact which shows at how early a period the ancient Egyptians had watched the effect of atmospheric and other influences on stones; and how wisely they profited by the lessons taught them by experience. They had learnt that earth abounding with nitre, from its attracting moisture, had the effect of decomposing granite; but that in the dry climate of Upper Egypt the stone remained for ages uninjured when raised above all contact with the ground. When therefore there was a possibility of its being exposed to damp, they based an obelisk or other granite monument on limestone substructions; and these last are found at the present day perfectly preserved, while the granite above them gives signs of decay in proportion to its contact with the earth subsequently accumulated around it. I am speaking of Upper Egypt, visited only four or five times in a year by a shower of rain; for in the Delta granite remains have been affected in a far greater degree than in the Thebaïd: nitre abounds there; and it is remarkable that the obelisks at Alexandria have suffered the least on the sides next the sea.

The Egyptians seldom used granite as a building stone, except for a small sanctuary in some sandstone temple; and in the later times of the Ptolemies one or two temples were built entirely of granite. But in the true Egyptian period the use of that stone was chiefly confined to the external and internal casing of walls, to obelisks, doorways, monolithic shrines, sarcophagi, statues, small columns, and monuments of limited size, and was sometimes employed for roofing a chamber in a tomb.

The durability of granite varies according to its quality. The felspar is the first of its component parts which decomposes; and its greater or less aptitude for decay depends on the nature of the base of which the felspar consists. Egypt produces a great variety of granite; and the primitive ranges in the desert east of the Nile, about thirty-five miles from the Red Sea, supplied the Romans with numerous hitherto unknown kinds, as well as with porphyry, which they quarried extensively in that district; but the granite of the ancient Egyptians came from the quarries of Syene, in the Valley of the Nile; and from these they obtained what was used for their monuments. It is from this locality that the name of "Syenite" has been applied to a certain kind of granite; it is, however, far from being all of the same nature, and a small portion only of the stone found there is really what we now call "Syenite." Already, at the early period of the third and fourth dynasties, between twelve and thirteen centuries before the Christian era, the Egyptians extensively employed granite for various purposes. They had learnt to cut it with such skill, that the joints of the blocks were fitted with the utmost precision; deep grooves were formed in the hard stone with evident facility; and it must have been known to them for a long period before the erection of the oldest monuments that remain—the Pyramids of Memphis, where granite was introduced in a manner which could only result from long experience.

Again, in the time of the first Osirtasen, about 2050 years before the Christian era, granite obelisks were erected at Heliopolis and in the Fyóom, and other granite monuments were raised in the same reign at Thebes; from which we find that even then the Egyptians had learnt how the damp earth acted on granite when buried beneath it; and this interesting question consequently suggests itself:—How long before that time must the stone have been used to enable them to obtain from experience that important hint which led them to place granite on limestone substructions?

I have already had occasion to offer some remarks on the mode of treating granite surfaces, which has been so ably detailed by Mr. Bell at the meeting of the Society of Arts * (on March 14); and I have stated that the Egyptians adopted the broad character of ornamentation in sculpturing granite very judiciously advocated by him; I will therefore only add that other good examples of such treatment may be found in the early crosses of Cornwall, Devonshire, and other localities in this country; where what has been (rather hastily) called the Runic knot—a design of entwined basket-work, common also in Italy, and other countries—the large scroll pattern also frequently met with on the same monuments, and numerous massive ornaments in relieved intaglio cut in the thickness of the stone, are instances of a style of decorative sculpture admirably suited to granite.

* Read at the Royal Institute of British Architects.

* See Journal *ante*, page 143.

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A NEW RULE FOR DEPTH OF KEYSTONE FOR SEGMENTAL OR ELLIPTIC STONE ARCHES.*

By JOHN C. TRAUTWINE, C.E.

I SUBMIT the following original rule for determining the depth of keystone for either segmental or elliptic arches of stone, as coinciding more nearly than any other with which I am acquainted with the practice of the best engineers:—

For first-class cut stone-work of hard material take ·36 of the square root of the radius at the crown; for second-class work ·4; and for brick or rubble arches ·45, of the same square root.

The following examples will show the accordance of the rule with existing structures both elliptic and segmental, in the first case, viz. with first-class work and materials. Our public works abound with cut stone arches having keys varying from ·36 to ·4 of the square root of the radius of the crown, and with rubble arches having keys from ·4 to ·45 of the same square root; but I have not thought it necessary to introduce them.

$$\cdot 36\sqrt{\textit{Radius at Crown.}}$$

Name of Bridge.	Span.	Rise.	Radius at Crown.	Actual Key.	Calculated Key.	Engineer.
	Feet.	Feet.	Feet.	Feet.	Feet.	
Cabin John aqueduct & roadway arch of Washington Aqueduct (a)	220	57¼	134¼	4·16	4·17	Meigs.
Grosvenor Bridge, across the Dee	200	42	140	4	4·26	Harrison.
London Bridge (new), Thames	152	29½	162	4·75	4·58	Rennie.
Gloucester Bridge, Severn...	150	35	150	4·5	4·41	Telford.
Claix Bridge, France	150	54	82	3·1	3·26	
Dora, Turin	148	18	160	4·8	4·55	Mosca.
Neuilly, as designed	128	32	160	5·3	4·55	Perronet.
Neuilly as it exists, on account of the settlement of the arches ...	128	...	250	5·3	5·69	Perronet.
Licking Aqueduct, Chesapeake and Ohio Canal	90	15	76	2·83	3·14	Fisk.
Staines Bridge	74	9·3	78 —	3 —	3·18	Rennie.
Bow Bridge, England	66	13·75	81	2·5	3·24	Walker & Burges.
Monocacy Aqueduct	54	9	50	2·5	2·55	Fisk.
Lugar Viaduct, Scotland	50	25	25	2	1·8	Miller.
James River Aqueduct	50	7	47	2·66	2·47	Ellet.
Reading Railroad, at Reading	31	5	26·8	1·66	1·86	Steele.
Semicircle	2·0	1·00	1·0	...	0·33	
Pont Napoleon Viaduct, Paris—small rubble masonry in cement; multiply by ·45	115·5	14·75	120	4	4·93	Couche.
Maidenhead Viaduct—brick in cement; multiply by ·45 ...	128	24·25	169	5·25	5·85	Brunel.

(a) This is the largest stone arch of modern times, or perhaps of any former period, unless we except the ancient bridge of Trezzo, said to have been 251 feet span. It was designed and its erection superintended by Capt. Montgomery C. Meigs, of the U. S. Topographical Engineers.

* From the 'Journal of the Franklin Institute.'

THE ARCHITECTURAL ASSOCIATION.

THE Architectural Association held their opening meeting and *conversazione* for the session 1860-61, at the premises of the Architectural Union Company, Conduit-street, on October 26th, the President, Mr. T. Roger Smith, in the chair. Several distinguished members of the Institute of British Architects were present, and there was an excellent gathering of the members and friends of the Association. The galleries were thrown open, and, in addition to the building materials and manufactures (noticed in detail at page 285 of this *Journal*) which have been for some time exhibited, there were three noble tapestries lent for exhibition by Mr. Cowan, and worthy of great attention: one a very fine example, designed by Pierino del Vaga, (the most celebrated, excepting only Giulio Romano, of all the pupils of Raffaelle), about 1537, for the Prince Doria; subject, Æneas and Dido, from Virgil;—another representing Æneas hunting;—and a third from Italy of the Cinquecento period, the subject being Anthony and Cleopatra. A considerable number of drawings and sketches produced by the Association's Class of Design were also exhibited, many of which were highly commended. It having been determined last session to offer prizes for the best sketches made by members of this class, and for the best essay on Street Architecture, the sub-committee appointed to award them reported—

"That the series has been contributed by eleven gentlemen, and consists of seventy sketches on fifteen different subjects, of which S. C. Rogers has illustrated thirteen; C. H. F. Lewes, twelve; H. A. Reeves, six; W. Oakley, six; W. Powell, six; W. T. Sams, five; R. Druce, four; E. A. Wyon, three; A. Ridge, two; Henry Ough, two; E. C. Morris, one. Your committee have pleasure in stating that many of the designs possess great merit, while the industry and perseverance of some members of the class are deserving of the highest praise. After mature consideration your committee have arrived at the unanimous conclusion that the prize should be awarded to Mr. William Thomas Sams; and as the present is the first occasion of the kind, they think it right for the guidance and consideration of future competitors to give briefly some of the reasons which induced them to come to this conviction. Your committee apprehend that the chief aim of the Class of Design is, not the mere collection of a number of hasty sketches, which, although they may contain the germs of meritorious designs, are in themselves likely to be both impracticable in execution and indifferently expressed in drawing; but inasmuch as the intention of architectural design is the execution of the subject, the point of previously issuing a syllabus is to secure the production of carefully studied drawings, which may be a test, as well of artistic composition and construction, as of the author's capability of expressing his ideas by drawing or colour where necessary. . . . . Your committee would call attention to the merits of several of the competitors, among whom Messrs. Rogers, Lewes, and Reeves, are conspicuous for the number and character of their designs, and deserve high commendation. . . . . .

With regard to the Essay on "Street Architecture," your committee regret that only one has been submitted for their decision. This is by Mr. Rogers, and, it is fair to say, contains many points of great excellence. The subject however is one of great interest, and it has been decided to submit it again to competition in the ensuing year. Your committee therefore thought it right to give to Mr. Rogers the choice, either of accepting an acknowledgement of the excellence of his essay, and withdrawing it and himself from the ensuing competition, or allowing it to stand over for next year, amplified and improved as they are sure on reflection he will consider desirable. Mr. Rogers has decided upon the latter course."

The chairman then presented to Mr. Sams a copy of Street's 'Brick and Marble Architecture,' the prize for sketches in the Class of Design.

The President delivered the inaugural Address, from which we extract the following:—

"It is cheering to advert to the state of things and prospects a year back, and to compare them with the condition in which architecture seems to stand at this present day. At the opening of our last session we were under the depressing influence of that forced stagnation under which all building operations had languished, and by which most had been arrested; and a repetition of the same evils was looked for by many of those best qualified to judge; while the threatening aspect of the political horizon seemed to bode ill for the arts of peace. Our profession, too, seemed to be in some danger of being split into two factions, so strongly were differences of opinion urged and maintained by the opposed advocates of the Mediæval and the Classical styles, provoked by events connected with the proposed erection of a new Foreign Office.

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We have not had any strikingly attractive competition, nor many buildings that have risen very conspicuously above the average standard of excellence,—a standard which, let it be remembered, is far higher in the present day than it has been for many generations. I cannot however help drawing your attention to one new building, on account of its exhibiting many of the characteristics of what we must admit to be a distinctive style that is really growing up, amid all our disputes as to whether we are to have any style of our own or no. I allude to the new Schools in Endell-street. In this building we have combined many of the characteristics which we could *à priori* expect to find in the architecture of a people who are peculiarly rich in means of information and travel, and among whom the arts of peace have been long and successfully cultivated; building in a city where no stone quarries are near at hand, and where the climate is bad for all perishable materials. We have brick, the proper London material, forming the material and giving the motive of almost all the ornamentation. We have a general prevalence of continental forms brought together from various districts familiar to English travellers; these forms being not however slavishly copied, but artistically adopted as types. We have a Gothic spirit pervading the whole building, a great deal of novelty and design, and a great deal of work requiring good workmanship and adapted to modern materials. This building is the more remarkable, because in the Stained Glass Works in its immediate neighbourhood is another example, less elaborate but not less characteristic of the modern build; while a short distance off stands a third example—I refer to the Northern School of St. Martin-in-the-Fields, in Castle-street, Endell-street—that has the merit of being one of the earliest, and of still remaining one of the best, attempts to introduce ornamental brickwork, with forms and details a good deal drawn from continental sources, into London street architecture.

Pointing in the same direction is the character of that gorgeously decorated Church not long since completed, in Margaret-street. The architect has not here had to contend with a disadvantage which more than any other impedes the progress of our art at the present day—namely, the preference by the public for an expenditure of the most parsimonious order, coupled with a desire for ornament in which effectiveness and profusion are more desired than congruity or good taste. In Margaret-street the outlay has been such as to secure the best resources available, and the result must be acknowledged to be most striking, and at the same time to partake of those characteristics I have already named—that is to say, brick exterior; general continental character, traceable to the influence of German, Italian, and French examples, as well as English; a very unfettered and successful, though at times extreme, search after novelty; and the command of very various materials and methods of building and of very good workmanship.

It is however to be regretted that either we or the public have let slip, during the past year, one precious opportunity for showing genuine artistic feeling, and introducing genuine novelty into our streets. I refer to the opportunity offered for the artistic treatment of the various Drinking Fountains lately erected. I do not mean to say that there is not here and there an executed example of appropriate design, or that there have not been many truly excellent designs made, and some published; but I do assert, and you will I am sure agree with me, that the design of the greater number of these drinking fountains, and even of the most conspicuous ones, is such as to cause sincere regret to those who reflect how much influence a number of simple, graceful, and thoroughly good objects of this class might have exercised on public taste, scattered as they are in the most populous parts of our towns and cities.

Among the matters of public interest for the year there have been several that bear directly on the progress of our profession, and that show an advance in public feeling for it; and others that denote progress generally, and a ripening of ideas on public matters, which is one of the things most urgently required to insure the advance of architecture. The great public works for improving the drainage of the metropolis, and for bringing the various lines of railway from its outskirts into the very centre of traffic, are not merely interesting in themselves, but are also valuable as indicating a spirit of general advance. On this account the commencement of the system of subways for the underground services of gas, water, and sewage, and the attempts vigorously prosecuted for obtaining the embankment of the Thames, and the improvements in progress in cutting new streets, are all cheering and encouraging. I cannot allude to the two last-named undertakings without reminding you of the tribute we are now unconsciously paying in them to the far-sighted genius of that greatest of post-mediæval English architects, Sir Christopher Wren, a man whose views were so much in advance of his day, that it is only now we are beginning to adopt the principles of metropolitan improvement he laid down in that masterly plan for the reconstruction of London after the Fire, which he prepared within less than three days of the catastrophe. It was only in Nash's day that we began to find it necessary to have our main thoroughfares as wide as those on Wren's plan, which equal Regent-street in breadth. It is only within our own day that the system of forming direct thoroughfares between principal points has been adopted as he proposed it; and it is only now—in fact it is not yet—that the necessity for embanking the Thames has been recognised at all generally: a work which, I need not tell you, formed one of the striking features of Wren's comprehensive scheme.

If the spirit of improvement be at work out of doors, we recognise gladly that it is not confined to the public, but has taken hold of ourselves in various ways. The last few years have witnessed in London alone the establishment of three purely architectural societies, and of a fourth embracing architecture. The Architectural Museum, the Architectural Exhibition, the Architectural Photographic Society, and the Society for the Promotion of the Fine Arts, are all of very recent growth, the last-named being formed within the year; and all have met with such a measure of general encouragement, as leads us to hope that, though not free from the risks and dangers that often assail young societies, they are all now fairly established and likely to prosper.

If the facts just enumerated are encouraging, it is not less so that of the three great wants of the profession one is now being taken into earnest consideration, which, by its settlement, will bring on a speedy satisfaction of the other two. We need a more recognised professional standard and a higher and more universally diffused tone of professional feeling;—we need a more defined system of professional education;—and we need a better understanding upon the matter of architectural competitions. Few, if any, will be disposed to gainsay the assertion that these three are all urgently pressing wants, and most will, I think, feel that the proposed examination and diploma is a step which, if taken, will be influential in procuring an improvement in the first of these respects, and ultimately, in all of them. The subject of architectural examinations is so soon to come under consideration in this Association, that it might perhaps be deemed prejudicing the freedom of discussion were I now to refer to it as fully as its importance warrants, and I do not, therefore, propose to pursue it far,—only I cannot forbear reading to you an extract from one of the architectural journals of Paris, which shows how severely the same pressure under which we in this country labour is felt there; a pressure, allow me to remind you, which has brought the expediency of some system of preliminary examinations and certificates of competency under the notice of this Association on more than one previous occasion. In the 'Encyclopédie d'Architecture' for September of the present year, and at the close of an article on professional responsibility, you will read as follows:—

"We will not conclude without once more remarking that if a trustworthy amount of capacity were required of those who take the title of architect, and that only on condition of taking out a certificate, it might be hoped investigations as to accountability for failures would become less numerous, the interests of those who commission buildings would be safer, and the profession would be raised in the eyes of all; for it must be admitted to be a subject of regret that it should be open to any chance comer with impunity to assume the title of architect, just as much as to the man who has devoted to his art and his profession many years of labour and study. . . . . The exercise of the profession of architect was formerly [in France] subject to the condition of being admitted by the corporation of architects, which admission did not take place till after an examination. In the present day architecture is looked upon as one of the liberal arts, which anyone ought to exercise without hindrance or formality. The authors of the 'Encyclopédie de Droit,' point out with justice that this state of things causes serious disadvantages. 'It is vain,' they say, 'to compare architecture to painting or to music; it is forgotten that a grand distinction obtains between them; painting and music are arts practised solely for gratification. In architecture, on the contrary, the lives and the property of citizens are directly concerned. A fault in construction may, should it lead to the fall of a building, seriously damage the interests of the owner, and en-

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danger the lives of inhabitants and passers-by. Regarded in this light, architecture is closely allied to the legal and medical professions: now these professions are subjected to tests of capacity intended to offer security to the public. Why should it not be so with architecture?' Accordingly, at the time of the discussion on Patent Laws, a deputy (M. Vatout) gave expression to the wish to see government giving to architects a regular organisation, and subjecting them to the necessity of obtaining a diploma."

This extract appears to offer an interesting corroboration of the views held by the promoters of the intended examinations, and having read it to you I will postpone till the evenings which are specially set apart for the discussion of this important subject any further remarks.

I have spoken, and have been glad to speak, of causes for self-gratulation and hope; but it behoves us to remember that with occurrences which call for congratulation have been mingled those which give rise to unfeigned regret.

It is not long since the engineering world was called upon to lose, in Mr. Brunel the most skilful, and in Mr. Stephenson the most practical, of its leaders, and since then our own profession has had to deplore the loss of the first architect in Europe—Charles Barry. The names of these three men will go down to posterity as of men standing out like giants amongst the able, the accomplished, and the experienced crowd who surrounded them in their professions in this, the middle of the nineteenth century.

Brunel was a man whose knowledge, skill, and daring as an engineer, was unapproached. His pleasure lay in overcoming difficulties, and his constructive triumphs will probably never be surpassed. But his greatest glory is that he was the founder of that system of ocean navigation in large ships, of which the Great Eastern steamship is one of the fruits; and his energy and determination (influencing the minds of those with whom he had to do to a wonderful extent) have probably caused this mode of transit to outstrip the advance of public opinion by many years, and have thus accelerated incredibly the progress of civilisation, by providing the means of cheap and rapid transit for merchandise and passengers. But for Brunel, it is almost certain that the Great Britain would never have been built when she was, and perhaps her dimensions would barely have been approached yet, and the Himalaya, the Persia, the Great Eastern, would have been things to us unknown and undreamt of. Perhaps posterity may accord to Brunel the meed of praise he so justly merits—his contemporaries have certainly failed to do so; perhaps they could hardly be expected, for many of the undertakings of which he had the guidance—particularly his railways—have not proved commercially successful, and have so far missed the aim of their promoters.

Less daring, but more sagacious, Stephenson has certainly done far less that was original; but he has done more to consolidate and render successful the great railway systems of the world than Brunel. His tubular system of bridges—the greatest novelty that he introduced—does not approach in importance the innovation wrought by the other in ocean transit; but his views were more practical, his results more in accordance with the aims proposed to him, and his works more usually remunerative to those concerned in them. To him is due the working out of a large part of that great railway system of which his father was the author and originator, for, like Brunel, he inherited a great name; and perhaps nothing higher can be said of him, or could have been said of any other man, however gifted, than that he was not unworthy to succeed to the name and the fame of old George Stephenson.

Barry, however, comes before us as the founder of a name, and not the successor to one. He made his own practice, his own standing, and by his own exertions raised himself from the situation of a young man so little known, that he is said once seriously to have entertained the idea of abandoning his profession for some other, to a position the most enviable that architecture has to afford. Barry, in conjunction with Rickman, Pugin, and others, may be said to have mainly set going the present active pursuit of Mediæval architecture; not that he was so ardent in his devotion to the cause as the others, or that he exhibited a trace even of the exclusiveness we have to deplore in many modern mediævalists, but that to his incessant toil and brilliant success with the great national building is due an example, the influence of which upon public taste has never yet been admitted to anything like its full extent; and that from his studio were dispersed a perfect school of able and skilled artificers, to whose training the works at Westminster were essential. Barry's favourite style was said to be the Italian Renaissance, and certainly his works which have that character stand unapproached for their excellence, while he, and he alone, seems to have been able, among the architects of our own time, fully to cope with the difficulties which this style presents to the designer; difficulties greater, probably, than any encountered in designing the most important Gothic works. The incessant personal vigilance, and the laborious toil of Sir Charles Barry, of Stephenson, and of Brunel, are lessons to us young men not to hope for excellence or to expect to attain the highest level even that our natural capacity and abilities are capable of attaining, without constant, careful, and oft-repeated study. The real artist is prodigal of his own pains, and we, if we wish, even at the humblest distance, to follow the track of so illustrious a man as Barry, must, above all things, copy his example as described so truly by Mr. Digby Wyatt. "His incessant labours first to learn and then to practise, again to learn and again to practise, and again, and again, and again to learn and practise so long as his physical energies could support the activity of his intellect, should convey to us all a lesson of profound humility, and a stimulus to exertion of the most active kind."

The profession has also had to lament the death of the noble and courteous President of the Institute of British Architects, the Earl de Grey, a man well fitted for his position, and to whose urbanity, both in presiding at the meeting of that body and in exercising hospitality towards it, many of my hearers will gladly bear witness.

I have already alluded to the cordial unanimity of feeling with which all members of the profession united to pay the last tribute of respect to Sir Charles Barry, and I was honoured, along with your then president, our excellent friend Mr. Penfold, to represent you on that occasion: I have now to advert, and do so with much pleasure, to the equally unanimous and equally cordial manner in which the highest official position connected with our profession was accorded, on the death of Earl de Grey, to the veteran professor whose delightful lectures so many of us have enjoyed, and whose absence from the Royal Academy we have all regretted. Long may Professor Cockerell live to preside over the body to which we, in this Association, are the junior society, and to which I hope we shall ever bear the same relation that one loves to see between the younger and elder members of a family, dwelling (as we now do) under one roof!

To those young men present who are not members with us, and to those of our members who are not in the habit of frequently attending our meetings, I would address myself for a moment, to point out to them that this society, and this society only, affords an opportunity for a young man to exercise himself in public speaking and debating, in writing essays for public reading, and in designing under as little restraint or constraint as is consistent with the fact of being before any public at all. The audience is a friendly one—I think, indeed, this society may be considered always to have been truly "a society of friends," and in that lies the secret of that affection which its members bear to it. The proceedings are not such as are calculated to embarrass; and the opportunity altogether is one than which no one desirous to acquire that self-confidence which is necessary for appearing in public can find a better. Many gentlemen, now famed for their skill in design, confess that they owe much of its development to our Class of Design; and more than one of those frequently before the architectural public with the pen or the voice, admit that they would have been dumb in public and unpractised at their desk, had it not been for the opportunities afforded them by this Association of finding out that they can speak and can write.

It may perhaps be desirable to explain to those who do not belong to us the nature of that highly important part of our constitution, the Class of Design, which might perhaps be designated by a happier name, because it is neither a class in the sense of there being a booking of names and an expected or enforced attendance, nor yet is it formed for the purpose of getting instruction from any one person. It is simply a meeting on the Friday evenings, intermediate between our regular meetings, of such members as like to attend and bring with them a sketch illustrative of the subject previously decided upon, a list of which subjects for this winter is contained in the syllabus in your hands. The sketches are handed round and afford subject for comment from the members present and the president, and,

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after this is over, the rest of the time is spent as the members find most profitable.

To meet a wish that had been expressed by some of the members to have papers read on subjects of elementary but fundamental importance, it has been arranged to devote four of our regular evenings to the discussion of the four simple but important subjects of "Foundation," "Masonry," "Brickwork," and "Carpentry;" and on these occasions it is intended that the paper succinctly introducing the topic should be supplemented by short statements of portions of the subject by other members who will be requested beforehand to prepare for this engagement. It is hoped that peculiarly valuable results may be thus obtained, and although on these four evenings the presence of members prepared with useful information will be sought to be secured with the greatest care, it is by no means intended to limit these preparations to those evenings—on the contrary, the committee earnestly desire that members should come down on all occasions prepared to discuss the subjects of the papers proposed to be read; and it is their intention to take some trouble to seek out and bring froward those members of their own body and of the Association generally, who may be supposed to be peculiarly conversant with the subject of any papers about to be read, and I sincerely hope that members will find a pleasure and an advantage in energetically seconding this resolution.

However it may be in some cases, there can be no excuse for half-heartedness in the pursuit of a profession like that of architecture, one which, more than any other, calls into equable use all the faculties of the mind, and does not neglect the body. At once sedentary and active, speculative and practical, artistic and business-like, the architect must combine the most opposite qualities, can make useful the most varied tastes, and can turn to profit the most comprehensive information; nor should he deem anything whatever, in the whole domains of science, art, or history, foreign to his studies. With a scope before him far greater than the most exalted faculties, the most untiring energy, and the most prolonged life could fully grasp, the architect has yet the satisfaction to know, that by limiting his efforts to one or two things at a time, it is within his reach to attain a very high degree of perfection in some, and at least an acquaintance with most, of the studies or forms of skill germane to his profession. This consideration furnishes an incentive and an encouragement to study and to labour with diligence; for although complete and universal success, even within the narrow limits of one profession, be unattainable to human power, it is quite impossible to say how near an approach to that perfection may be practicable. In this struggle, and with these objects before us, we feel that we can help one another, and on that ground it is that this Association was formed; and it is from a conviction that our friendly co-operation here has been of value to us, and will be of more value still the more energetically we prosecute it, that we adhere to this Association and desire its advancement. Let us then continue this mutual assistance, and maintain and redouble our individual and collective exertions.

Lastly, let us all bear in mind that to the keeping of each one of us is committed a portion of the honour of the profession. Circumstances may put a brilliant career beyond the reach of some, of many, of all of us; but a stainless one is possible to all, and nothing short of that is allowable to any of us. In integrity and honour then, let us be perfect—in friendship undivided; and in study and practice let us resolve each to know no limit short of his utmost and his best, taking as a maxim of practical life those inspired words: 'Whatsoever thy hand findeth to do, do it with thy might.'"

[Among the letters read from gentlemen unable to be present was one from Mr. Tite, M.P., announcing his determination to place at the disposal of the Association an annual prize. The following is an extract:—"I beg you to announce to your committee that I shall be happy to place at their disposal £5 per annum, to be distributed in prizes in books, or in any way best calculated to promote the very praiseworthy objects of your Association. If you will kindly call upon me, I will endeavour to make arrangements for the regular payment annually of this sum, at the period of the year most convenient for your purposes, and also to say a word as to the objects to which the prize or prizes may be devoted."]

WOODEN *v.* IRON BRIDGES.

A correspondent of the *American Railroad Journal* writes—

"In your journal have appeared recently two articles, the one an extract from the annual report of the Alexandria, Loudoun, and Hampshire Railroad; the other headed, 'Bridges on the Grand Trunk Railway of Canada.' In both of these articles it has been attempted to show that wooden bridges are more economical than iron bridges, not only at first cost but even in the long run.

The figures and arguments set forth in those articles may be satisfactory enough to the writers thereof, and to the superficial reader, but the engineer who takes into consideration all the facts bearing upon the subject, and who possesses sufficient knowledge of the first cost of wooden and iron bridges, and the expense of maintaining them, will arrive at very different conclusions; and as this is a matter of considerable importance to the railroad interest of the country, it is but proper that erroneous statements should not remain uncorrected.

The case cited in the last-named of the two articles in question, and upon which the conclusion as to the first and ultimate economy of wooden bridges is based, is one not of general application. A wooden bridge of 150 feet span is stated to cost $6000, or $40 per foot lineal; and an iron bridge of the same span is said to cost $30,000, or $200 per lineal foot. Now if an iron bridge of 150 feet span is to cost as much as that, nothing is clearer than that iron bridges should never be built upon this continent. Fortunately, however, our American engineers, not being wedded to the English tubular plan, understand how to build iron bridges, of the same and of greater strength than the best wooden bridges, for $50 and $55 per foot, or from $7500 to $8250 per span of 150 feet. At such prices the comparison of cost of wooden and iron bridges will be somewhat different.

The average time a wooden bridge lasts is about eight years. If its first cost is $6000, and it requires rebuilding eight years after its construction, then the cost of the new structure will be $6000 + compound interest for eight years = $3628 + cost of new structure = $6000, making in all $15,628. The iron bridge at that time costs $8250 + the compound interest on that sum for eight years = $4988, or $13,238; showing a difference of $2389 in favour of the iron bridge after the first eight years.

But this is not all. We have estimated for the reconstruction of the wooden bridge only $6000, and the reconstruction was to be required after the expiration of eight years; while the fact with which everyone is familiar who has had the keeping of wooden bridges in repair is this,—that the reconstruction commences three or four years after the bridge has been built; and that it cannot be done at the rate of $40 per foot as in the original construction, but that it costs at the lowest estimate more than twice that amount. It is generally the case that after three or four years some of the timber in a wooden bridge require replacing. It is very difficult and expensive to take out a plank while the trains have to run over the bridge. Expensive scaffolding has often to be resorted to, and the mere preparations to replace one or two pieces of defective timber are often more costly than the required repairs. It is difficult to estimate the exact cost of thus keeping wooden bridges constantly in good order; and unfortunately our railroad reports do not show an exact account of the cost of each bridge on the road; but everyone who has any practical knowledge of the subject can judge from its nature that the reconstruction of a wooden bridge, under all the disadvantages under which it has to be done, cannot cost less than double the cost of original construction. Hence it is safe to say, that a wooden bridge of 150 feet span costs in round numbers $21,000 eight years after construction; while an iron bridge costs only $13,000 in the same period.

But this is not all. A wooden bridge requires constantly a watchman, at about $360 per year, which is equal to the interest on a capital of $6000. An iron bridge being proof against fire needs not to be watched. Hence, if the question is simply one of first cost and maintenance, then from the day the wooden bridge is built its cost must be considered equal to $12,000 ($6000 for cost proper, and cost of watching equal to a loan of capital of $6000), while the iron bridge costs only $8520. But this is not all. Wooden bridges are often destroyed by fire, in spite of the watchmen. The loss of a structure in that way is not to be estimated by its original cost, for there is the loss occasioned by the interruption of the traffic for days and weeks, the cost of erecting and maintaining temporary works until a new structure can be prepared, &c.

There are few roads which have not severely felt the uncertainty of wooden bridges; and few managers of railroads, if they were only allowed to take the ultimate good of their company into consideration, would ever erect another wooden bridge. But they are forced by necessity to adopt the cheapest expedient to get a road in running order and money-making condition, disregarding for the time the consequences. As a temporary expedient wooden bridges will do well enough, but when it is attempted to show that they are 'the very thing,' we must solemnly protest."

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INSTITUTION OF CIVIL ENGINEERS.

Nov. 13.—GEORGE P. BIDDER, Esq., President, in the Chair.

BEFORE commencing the ordinary business, the President reminded the assembled members that at the opening of the last session they had heard from the then President, Mr. Locke, a most feeling address announcing the decease of those two distinguished members of the profession, Mr. Brunel and Mr. Robert Stephenson. How little was it imagined that the lips which then uttered the fervent eulogy upon the memories of his departed friends would so soon be hushed in the silence of the grave. Another of their leaders had passed away, cut off in the prime of life, and in the full vigour of his intellect. In Mr. Locke the profession had lost one of its most eminent members, whether regarded professionally or socially, and the Institution one of the ablest Presidents that had occupied that distinguished position. Sprung originally from that great nursery of practical engineers, the works at Newcastle-on-Tyne, Mr. Locke acquired there his mechanical knowledge, and his unbounded confidence in the powers of the locomotive engine. He was soon transplanted to co-operate with the late Mr. George Stephenson in several of his early works, but nearly at the commencement of the construction of the Grand Junction Railway, a separation occurred, into the causes of which it is as unnecessary as it would be invidious to enter. This separation between the master and the pupil occasioned painful feelings at the time, but it must now be looked upon as an inevitable necessity for the more rapid development of the railway system, at a period when the existing modes of transit had become totally inadequate for the requirements of commerce and for the growing wants of civilisation. It had always been observed, that whenever the necessities of society required any peculiar development of talent or any particular invention, by the interposition of an all-wise Providence the man and the knowledge were forthcoming to provide for these growing requirements. On the introduction of railways it was requisite that a vast amount of mental energy and physical exertion should be employed, in order to render the development as rapid as possible. Mr. Locke possessed peculiar qualities of mind, which secured for him the confidence of capitalists, by whom the construction of the Grand Junction Railway was entrusted to him.

At an early period of the railway epoch he became the engineer of the South-Western line, whence he almost naturally sought for, and ultimately accomplished, the extension of the system to France; where, in the construction of the Paris and Rouen, and Rouen and Havre lines, he introduced English capital, English workmen, and English contractors, and initiated the continental railway system. He was thus the first who promoted the establishment of the present rapid communication between the great commercial capital of Great Britain and Paris, the fashionable metropolis of the continent.

Returning to the field of his early labours, he undertook the extension of the line from Preston to Carlisle, and thence to Glasgow, Edinburgh, and ultimately to Aberdeen, thus becoming also the pioneer to the Scottish railway system.

Without entering minutely into the details of his professional life, which would be given in the official memoir, it would be admitted from what had been stated that Mr. Locke was entitled to be considered one of the great engineers of the period, and a distinguished pioneer in the introduction of the railway system.

There was a curious coincidence in the circumstances of the decease of the three distinguished men who had been removed within little more than a year. Each one had departed on the eve of, or at the completion of, some great work. Mr. Brunel might be said to have died as the Great Eastern steamer commenced its trial voyage. Mr. Robert Stephenson was taken away on the eve of the completion of the great Victoria Bridge over the river St. Lawrence, Canada; and Mr. Locke's decease occurred on the completion of his long-cherished project—the extension of the narrow-gauge line to Exeter, the capital of the West of England.

These remarks would be very incomplete if no allusion were made to the distinctive features which marked Mr. Locke's professional career. They would be best understood by extracts from the able address he had made to the members on assuming the presidential chair only three years ago. He then said,—

"Let us consider the principle on which public works are now undertaken,—the motives that supply those abundant means by which alone they become possible. It must be seen that the problem proposed on such grounds to practical science is, not merely the execution of certain works, but rather their arrangement and construction in a manner calculated to realise the objects in which they originate. . . . . .

Beyond this, observing the springs from which our profession draws its support, and the relation which it bears to the voluntary employment of private means in public works, the significance of financial results, as final exponents of their success or failure, must be apparent. . . . . .

In every point of view, therefore—whether especially considering that it is the triumph of science to solve the whole of every problem submitted to it, and not a part only, or regarding its general relations to the objects of modern society in inviting its exercise—it will be seen that the financial result of their joint operation is not their least important feature; and that the appreciation of this side of the question really concerns the engineer no less than the statesman or the capitalist."

Those who have watched the career of Mr. Locke are well aware how pertinaciously he adhered to these rules. It was not that he feared engineering difficulties, for when inevitable he encountered and overcame them with skill—as, for instance, in the works of the Manchester and Sheffield Railway. But his great anxiety, and which secured for him the confidence of a large body of capitalists, was to attain his object by avoiding difficult and expensive works, from a desire that all the works on which he engaged should be commercially successful. The abnegation of professional renown arising from the construction of monumental works, whilst establishing his reputation as an economical engineer, induced him to turn to the locomotive engine, and to tax its powers (in which he had, from the earliest period, the greatest confidence) for overcoming steeper gradients than had hitherto been deemed compatible with economy and safety. In this he was very successful, and, when viewed in conjunction with the previously-mentioned general features of his professional life, it must be conceded that the decease of Mr. Locke has caused a gap in the profession which will long be felt.

It would be improper to conclude this hasty sketch without alluding to the extent to which both Mr. Locke and Mr. Robert Stephenson had acquired the confidence and esteem of a large circle of friends in the House of Commons. They had ably maintained the dignity and independence of an important profession, which should always be adequately represented in parliament. They went there without any personal objects beyond that of fair ambition to attain an honourable position—whilst there they were eminently useful; and it might be hoped that before long other active useful members of the profession would assume their places in the House.

Of the urbanity and impartiality with which Mr. Locke had acquitted himself of the duties of President, it is unnecessary to say a word; all that he had said and done was so recent, and had been so universally approved. The Members of Council, and those who had enjoyed his friendship, would lament the loss of a genial companion, and the Institution a valuable and influential member.

The Discussion upon Mr. Scott's paper, "*On Breakwaters*, Part II," which was commenced at the closing meeting of the last session (*ante*, p. 212), but not then concluded, was continued throughout the evening.

It was remarked that in shallow surface-waves the action of the oscillating water might be successfully resisted by pitched stone walls, concave and cycloidal outwardly. But a true breakwater must produce tolerably smooth water, not in the case of oscillating waves in shallow foreshores, but in heavy waves and deep water. A ground swell consisted of Waves of Translation accompanied by Oscillating Surface Waves. These two classes must coexist in deep water after a heavy storm. Heavy "rollers" like those off the Cape of Good Hope were waves of translation, consisting of vast masses of solid water moving in one direction with great velocity. Their action was nearly as powerful at a great depth as at the surface. They were like the tidal "bore" at the Hooghly, or the Severn, or the Dee. They could not be diverted, but must be stopped or broken. This could only be done by a mass heavy enough to be undisturbed by their momentum. A wall of vertical masonry was considered to be the best reflector—cost and durability apart; but a wall inclined at an angle of 45° would also reflect a wave of translation, and at this inclination large blocks judiciously placed would not be disturbed, even although a considerable breach was made in the wall near them. When any approximation to the reflection of the wave by walls not too remote from the vertical face was abandoned, then reliance must be placed on breaking the wave. For breaking the heavy ground swell, a long sea-slope, with the convex section rounded off at the forefoot, was thought to be the most suitable. The intention in this case was to cause the great wave to begin breaking as early as possible, to make the breaking last some time, and thus insure the diminution of its momentum being as complete

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as possible—the wave breaking on itself, and not upon the stones. In practice, both the ground swell and the surface wave—or both waves of translation and of oscillation—had to be contended with. An upright wall, also a convex sea-slope and a vertical pier above, dealt with both. But it was contended that an outer convex sea-slope of rubble, with a retired vertical wall and a retiring slope on the top of it, was a better arrangement. Floating breakwaters did not destroy waves of translation; nor did open piles and gridirons stop waves of oscillation; but a number of parallel rows of piles would diminish waves of translation.

It was remarked that Kingstown Harbour had been constructed on the long-slope principle—the slope being 5 to 1—at a total cost of only 1*s.*6*d.* per ton, an amount which had been exceeded by the cost of the scaffolding alone of some modern public harbours. The great breakwater at Portland was also constructed on the same system, and the present engineer had stated in evidence that vertical walls would only be necessary for quays, or wharves, on the inside. In deep-water piers the long slope appeared therefore to be preferred to the upright face.

It was contended that the pier at Blyth could not, with propriety, be adduced as an example of the success of a work with vertical walls when exposed to a heavy sea. It was constructed on a ledge of rock, the surface of which was from 6 feet to 10 feet above the level of low water of spring tides, having a breadth of about 400 feet seaward of the pier. The seaward margin of the rock bore the name of the "Sow and Pigs," and was situated at a distance of 1100 feet from the foot of the pier, and thus protecting it from heavy seas, which were broken half a nautical mile from the line of the pier. In addition to this great natura protection there also existed, at 60 feet seaward of this work, an old long-slope pier, which extended for a length of about 700 feet from the shore. The pier at Blyth was, however, a cheap and proper one for the situation.

In reference to Table Bay it was stated that the chief danger to shipping and to any breakwater in course of and after erection, arose from the gales from the north and north-westward. These were always accompanied by a heavy swell, the waves of which, from the configuration of the bottom over which they passed, assumed the character of mountainous "shoal-water waves." The greater portion of the breakwater would have to be constructed in water 6 or 7 fathoms deep, or a short distance outside of the breaking point of the crest of the waves in the north-westerly gales. Looking at the model of the breakwater proposed by the author, and recalling to memory the volume and the peculiar character of the waves, the condition in which they would arrive at the proposed structure, the momentum and velocity with which they would be travelling, as well as the possibility of gales occurring during the progress of the works—the opinion that the proposed structure was inapplicable could not but be concurred in. And even if the work could be completed, so far from the waves being broken up or neutralised, it was believed—to use a sailor's expression—they would go "clean over it;" and that by the action of a succession of such waves the entire fabric would be speedily reduced to the state of a dangerous shoal-water reef in the entrance of the Bay.

It was urged that no uniform rule could be laid down as to the best form and material for maritime works. It might be safely stated that the comparative suitability, economy, and duration of any hydraulic work would be almost, if not entirely, proportionate to the amount of knowledge and skill bestowed on the preliminary survey of the physical features and hydraulic phenomena of the locality. The misconceptions arising from the terms "wave of oscillation" and "wave of translation," as applied to the wind waves of the ocean and sea coast, had, it was thought, contributed in no small degree to many crude and impracticable schemes which from time to time were brought forward as "universal" modes of constructing breakwaters and sea defences.

It was observed that the discussion resolved itself into two separate questions—the one as to which was the best form of wall, in a theoretical point of view, to resist a deep-sea wave; the other, the cost of securing that form; and the consideration of cost might lead to the adoption of the less perfect line. It was argued that the vertical wall was preferable to either the cycloidal or the long-slope systems; and the objection to vertical walls, that they were liable to be breached, was not considered to be valid. If stone were abundant and cheap in the neighbourhood of the works, a rubble breakwater, though requiring more than ten times the amount of material which might be necessary for an equally strong vertical wall in the same situation, might yet be the more economical structure. But where stone was scarce and dear, the pierre-perdue system was inapplicable. In fact, each case must be separately considered.

It was thought that as the hydraulic laws which regulated the motion of waves were fixed and immutable, although the local circumstances vary in each, yet some definite conclusion could be arrived at as to the best form of breakwater, first, for the deep-water oscillating wave, and secondly, for the shoal-water wave of translation, or wave of percussion. It was believed that the long rubble slope, say of 7 to 1, between the levels of high and low water, which converted the deep-water oscillating wave into a wave of translation, was an error of construction, not only as regarded original cost, but also future maintenance of the works. The long sea slope was exposed both to the percussive action of the waves of translation, and to the recoil of the sea, or what sailors termed the undertow of the wave. In shallow water, with insecure foundations, the cycloidal form was looked upon as the best; but in deep water, for resisting the simple oscillating wave, the vertical wall would be found to be the most economical and durable, and the proper form.

It was contended that in constructing harbours of refuge the object need only be to break the great force of the waves, and not to endeavour to secure such smooth water within as to enable trade to be carried on, which should be done in an interior harbour alongside quays. There were several advantages in keeping the superstructure low, say not above high water of equinoctial spring tides. In a military point of view such a breakwater would act as a glacis to vessels of war inside, over which they could deliver their fire, and be themselves protected to a great extent from an enemy outside. It was asserted that the expense of building the counterforts shown in the design proposed by the author, would be greater than building a second longitudinal wall; and that the cost of the whole work would be much in excess of what had been estimated. Also, that a heavy wave, striking upon the gridiron surface formed by the iron girders spanning the intervals between the counterforts, would have a greater tendency to run up and over the work in a body than to pass between them and be divided.

In reply it was assumed that the principle which had been contended for seemed now to be admitted,—namely that the vertical face was the best form hitherto employed. But it was thought by some that the vertical face could only be obtained at great expense. Cost, no doubt, must decide the question; but by adopting the system advocated in the former paper, of first constructing a timber breakwater, and subsequently facing it with stone, it would be found that the vertical face was the cheapest as well as the best. The gridiron breakwater, it was assumed, would be better still where there was a heavy sea and small rise of tide; and was the form best fitted to deal with waves of great magnitude. It had been said that rollers could only be broken by opposing mass to mass. The object of the new design was to break the wave, without opposing mass to mass. It had been proposed to place an isolated mass of stone-work parallel with the breakwater seaward. This would be effective, but it would constitute a second breakwater, and as the slopes must be long, it would be expensive. It had been objected that the water passing between the girders would strike the counterforts obliquely, and that they would receive the whole force of the blow. This was tantamount to saying that the sea came end on, and that there was no grating. The only surface exposed to the blow of the sea was iron. As to the objection that the water would pass through, and reproduce a wave, supposing the worst case, that the water passed through a number of spaces at the same moment, each body of water in falling would produce a wave; but these small waves would neutralise each other. The misconception arose from considering a sloping screen with horizontal bars to be the same as a vertical screen with vertical bars, and ignoring the fact, that whereas in the latter the water passed through at the same moment, leaving the continuity of the wave unbroken, in the former it passed through in detail, and at successive periods of time, whereby the continuity was destroyed. The principle of a screen with horizontal bars had been tried on a small scale, and was successful. It was thought that the only forcible objection that had been taken to the new form was, that part of the wave might go over the top of the slope. Now if a slope 80 feet in width was not sufficient to prevent that, then 100 feet or 120 feet could be tried; and even then it would only cost £126 per foot run, which, it was contended, was less than any other form to be equally effective. The breakwater could first be built 80 feet in width, and any addition could be made afterwards; whilst every addition to the efficiency of a vertical wall by increasing the height diminished its strength, every increase to the efficiency of the proposed work added to its strength; because every foot added to the height involved an increase to the width of two feet. The counterforts would be composed of massive blocks of rubble masonry, so interlocked and set in cement that they would constitute one solid mass.

With respect to the portion of the breakwater at Blyth before the meeting, it was apprehended that there had been some misconception regarding the principles upon which it had been constructed. The straight part of this portion of the work was so like, in external appearance, some other works, that it had been assumed by many to be similar, whereas in principle and action it was entirely different. The fundamental idea had been that the work should rest on, and not be attached to the ground; but that its stability should be entirely dependent on the weight of the stone filling, and independent of any ground fastening. The second object was so to combine the timber and stone that they would form one whole. Both these objects had been effected, but attention was drawn to the fact that an apparently slight change in either the form, or in the details of construction, would be attended with great danger to the structure. It was observed that there were other peculiarities, one being the great facility afforded by the system of framing the timber on shore, and depositing it complete in its place. It was thought necessary to make these observations because this system of construction was being adopted elsewhere, and if attention was not directed to these unimportant details, in reality involving principles, success could not be expected.

In closing the discussion it was remarked that the question of breakwaters was still in an unsatisfactory position, as there were but few facts

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or data upon which to form an opinion. It would be interesting to be informed what was the cost per lineal yard of the breakwater at Alderney, in 20 fathoms water, where the stone had to be quarried by the contractor, as contrasted with that at Portland in 10 fathoms water, where the stone was quarried by convicts. The profession was fairly entitled to ask, that those engineers who were employed in constructing important national works, which were paid for out of the public exchequer, should be called upon to furnish detailed particulars in reference to their cost and the mode in which they were carried out.

Nov. 20.—The paper read was "*On the River Orwell and the Port of Ipswich.*" By GEORGE HURWOOD, M. Inst. C.E.

It was stated that the river Orwell had a north-westerly direction from the harbour of Harwich upwards to the town of Ipswich, where it met the lock of the inland navigable river Gipping; the distance from Harwich to Ipswich being 12 miles. Towards the close of the last century the river had been so encroached upon and neglected, that the trade and commerce of the port of Ipswich was seriously affected. At that time there was only 5 feet of water at neap, and 8 feet at spring tides, at the quays; so that it was usual for vessels to load and unload their cargoes from and into small craft at Downham Reach, about three miles below the wharves. A committee of the leading merchants, shipowners, and inhabitants therefore determined to take the opinion of Mr. W. Chapman, civil engineer, of Newcastle-on-Tyne, who submitted a report in 1797, accompanied by two distinct plans and estimates of the probable cost of carrying each into effect. In his report Mr. Chapman investigated the causes of the bad state of the river above Downham Reach, which he attributed partly to the great irregularity of its course, but mainly to the reduction in the quantity of tidal water, due to the silting up of the bed of the river, and to the inclosure of 120 acres of land above Stoke Bridge, 60 acres below that point and Nova Scotia, and from 6 to 7 acres between the Cliff Brewhouse and the Rope Yards.

To remedy these evils Mr. Chapman proposed to construct a tidal or sea lock near Downham Reach, and a canal, with a navigable depth of 16 feet, from thence to a basin before the quays. The other plan was to improve the river itself, by deepening the channel, and by cutting off the abrupt bends, thus reducing the length in the distance of 12 miles by 1 mile. He pointed out, however, that straightening alone, without providing an additional current of water, would not be productive of sufficient effect. But he was of opinion that if an equivalent quantity of tidal water could be obtained to that which formerly flowed over the land before it was embanked from the river, this, in aid of the greater straightening of the course, would produce the desired effect. The estimated cost of the two plans was £27,000 and £17,000 respectively. Mr. Chapman gave a decided preference to the former, and in subsequent reports urged its adoption. Finding that the expense was objected to, he, in order to reduce it, suggested that the navigable depth should not be made more than 13 feet, and he proposed to place the entrance lock at Preston Reach, so as to shorten the length of the canal.

The bent of public opinion was against the adoption of the former project, and in the year 1803, at a meeting of the inhabitants, it was resolved to apply to parliament for power to improve the river in accordance with the second plan. This induced the Act of 1805, which virtually took the managing power out of the hands of the corporation, and placed it in those of the principal merchants, shipowners, &c.

The first work of importance undertaken by the commissioners was the making of a new channel at Cliff Reach. About the year 1819 a similar work was carried through Round Ooze, to avoid the circuitous and difficult route by John's Ness. In the year 1821, under the advice of Sir W. Cubitt (Past President, Inst. C.E.) a new channel was cut from the upper end of Limekiln Reach to the lower end of Hog Island Reach. These works so improved the river, that in 1826, vessels drawing about 11 feet of water could reach the quays at spring tides. Yet notwithstanding the outlay which had been incurred, the commissioners had saved from the revenues of the port and the river a sum of £25,000. Further improvements were therefore determined upon, and under the advice of the late Mr. H. R. Palmer (V.P. Inst. C.E.) powers were obtained in 1837 to construct a wet dock. In 1842 the works were sufficiently advanced to maintain the float; and in 1847 a new channel was finished through Black Ooze. The bends from Cliff Reach to the Upper Hearth Point, the Lower Hearth Point, and also Wherstead Reach Point, where awkward projections existed, had all been considerably reduced. The channel from the lock of the wet dock to the deeper water near Downham Reach, had been dredged to a depth of 1 foot below the top of the lock cill, and shoals were removed as soon as they were formed. The effect of these continuous and combined operations had been to give a depth of water from the sea to the wet dock of 16 ft. 4 in. at average spring tides, and an average low-water depth of not less than 3 ft. 3 in. When the wet dock was opened in 1842, vessels of about 13 feet draught of water could reach the dock at average spring tides. The object had since been, not only to increase the depth by dredging, but to bring the channel course into a good condition, and to regulate the capacity where necessary, so as to make the navigation easier. Every available means had been adopted to encourage the easy flow and ebb of the tide, and to prevent any encroachment upon space previously covered by tidal water, particularly in the upper part of the river, and wherever opportunity offered to enlarge the receptacle to receive it; as the author believed that the preservation of the river entirely depended upon the tidal operations. There was a rise and fall of tide at Harwich of 13 ft. 6 in., and at Ipswich Dock of 13 ft. 7 in. The rate of spring tides within 2 or 3 miles of Ipswich was about 1¾ knot per hour. The duration of the flood and of the ebb tide at Ipswich Dock was nearly equal; and the stationary state of the tide at low-water was of short duration, and seldom perceptible. The cost of the wet dock, and of the works connected with it, amounted to about £130,000.

It might be stated that before the commencement of the works the depth of water to Ipswich Quay was only 8 feet, whereas it was now 16 ft. 4 in. At the former period the tonnage of the registered vessels belonging to the port was less than 7000 tons, whilst at the present time it amounted to 16,274 tons.

The communication was accompanied by an Appendix, including copies of the reports made by Mr. Chapman, Mr. Palmer, and the author, as well as of the various forms used in recording the transactions of the port, and detailed particulars of the cost of all the works.

THE HISTORY OF ARCHITECTURE.

AT the meeting of the Liverpool Architectural and Archæological Society held in the Royal Institution, Liverpool, on the 14th ult., a very able and interesting paper was read by Mr. Samuel Huggins, entitled "An Historical and Critical review of the various Styles of Architecture that have been practised in the world from the dawn of art to the beginning of the present century:" illustrated by a coloured Chart of the History of Architecture.

The author said that though the secretary's circular promised an independent paper illustrated by the chart, he had thought it best to reverse their relationship, and make the paper an illustration of the chart, which latter represented the origin and various successive transformations of the architecture of the Greeks, involving the rise, chronological sequence, relationship, &c., of the principal styles that have been practised from the dawn of art to the present time. It was embellished by various chronological tables: one, of the great ruling powers; another, of the principal architects; a third, of the great typical edifices in each style; and a fourth, of great events having an influence on architecture, which latter he had found so numerous as to show that, if the history of architecture was not identical with the history of the world, it was at least an appendage to human history, and organically developed out of it.

He began with the Egyptian style, the origin of which was lost in the night of time, beyond the ken of historic record. To it belonged the oldest buildings on the face of the earth, irrespective of the Pyramids, which, though sublime objects, could scarcely be considered as architecture at all. Unlike the subsequent styles, which invariably manifested progress for a certain portion of their career, the course of Egyptian was one of decline, the oldest buildings being the greatest and purest in style. The Temple of Karnac was the oldest of temples, and perhaps the sublimest building ever reared by human hands. The Egyptian and the Assyrian were the Adam and Eve of the architectural styles of the world. The Egyptian gave to the Greek some of its most beautiful elements and sublime characteristics, and shadowed forth the Doric order, while the Assyrian suggested the Ionic.

After describing the Assyrian style, which was chiefly illustrated by palaces, the remains of which had been within the last few years dug out of the earth, he went on to the Persian, a style almost identical with the Assyrian, and which continued to flourish at Pasargada and Persepolis till the fall of the Achæmenian dynasty and conquest of Persia by Alexander the Great.

The style of the early inhabitants of Greece was the Pelasgic, which under the Dorians was there mingled with Egyptian and Assyrian elements till it grew into the Hellenic or true Greek, the first appearance of which was at Corinth, under the Cypselides, in a form almost as massive as that practised in the valley of the Nile. This originated the archaic age of Greek art, which was followed by the more perfect age of Pericles. Of the style as it existed at this time, he would only say that every increase of knowledge went to confirm the belief that it was the most pure, noble, and perfect architecture that ever existed—an architecture in which the most intellect and refinement of feeling was embodied, and that involved the subtlest graces and excellences ever expressed in stone. The noblest example of the style—the Parthenon, embodied more intellectual

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beauty and æsthetic perfection of form and detail within the same compass than any other building in the world.

The period at which such architecture was produced, both Classicist and Mediævalist must allow to be the most illustrious epoch to which we could point in the history of architecture. As might be expected, it was otherwise illustrated; and the genius of architecture did not reach to so distinguished an eminence unaccompanied by her sister arts; not only by sculpture and painting, which were then in their zenith, but by poetry and "divine philosophy." The Homeric period of the Grecian epic was long past at the time in question, but it followed close upon that of Pindar and the Greek lyric muse; and it was contemporary with the glorious dramatic era of Æschylus, Sophocles, Euripides, and Aristophanes; rendered still more illustrious by the pure doctrines and bright example of the greatest philosopher of antiquity, who was then living at Athens—Socrates; while it heralded the philosophic age of Plato and Aristotle, and the no less brilliant era of Demothenes and Isocrates.

The two styles, Greek and Etruscan, flowed together to form the Roman, into the defence of which, against recent depreciation, he warmly entered. The Roman style in the time of Augustus, its great period, was practised from the shores of the Atlantic to the Black Sea and Persian Gulf, and all round the Mediterranean, save Egypt. With the exception of the Egyptians, it was the only style of the civilised world; and notwithstanding all that had been urged against it, he thought it was not unworthy of its great extent of practice. St. Paul's Cathedral, London, was Roman architecture as the Romans used it; and neither the Greek nor the Etruscan alone could have embodied such a composition, and no Romanesque, in which the two styles were fused into one in the manner it is said the Romans should have united the styles, could have attained to half its grandeur.

After describing the style of the middle Persian Empire, which had an important bearing on subsequent styles, he entered on a description of the Christian career of architecture. Under the influence of Christianity, its hatred of all associations of paganism, and its new requirements, the Christian Romanesque was generated, which style was no sooner formed than the Byzantine commenced its separation from it. The Byzantine style, as Hope says, originated in a wish on the part of the architects of Constantinople, after its separation from the Western Empire, of giving to the architecture of Christianity a form wholly different from that of paganism. The Byzantine was the style of all nations of the Greek church, or that remained of Christian in the East, and who did not embrace the faith of Mahomet. After giving a full description of the style, which in course of time became divided into several distinct branches—European, Western Asiatic, Armenian, and Georgian Byzantine, the latter coming down to near the present time—he went on to the Saracenic group of styles, which were developed out of the Byzantine, viz., the Persian, the Syrian, the Egyptian, the Spanish or Moorish, and the Indian and Turkish; of which styles he gave an interesting description, characterising them as the most elegant and refined that have been anywhere practised, and that had a great influence through the medium of the Crusaders on the decorative development of the Gothic. It was devoutly to be hoped, for the sake of the general interest of architecture in the world, that the increased intercourse with Europe would not further interfere with the practice of these styles, and prove an extinguisher of so much that was beautiful and poetic.

Returning to the main stem of the history, the author entered on the subject of the Gothic styles. From the rude attempts of the various tribes of barbarians who overthrew the Roman Empire, to imitate the edifices of ancient Rome in the erection of Christian churches, an entirely new system was originated, called Gothic, which for a time was all one nebulous chaotic mass. But in process of time it consolidated, branched out, and spread, with the faith which called it into existence, into the different countries of Europe, where it exhibited local varieties according to the character and energies of the different races who adopted it. As the vernacular languages of modern Europe pushed themselves through the Latin as the exponents in each particular country of the popular thought, so in like manner the Gothic styles of architecture made their exit from the Roman. Of these Gothic styles the Lombard was the first that became formed into an independent style; the German was the next, which was the finest of the round Gothic styles, and the one most worthy to stand as the representative and typical style of the class. He described the career of Gothic in France, England, Spain, Belgium, Scotland, and Ireland, and traced them through all their different periods to the time when their course was arrested by the Reformation and the revival of Classical art and other causes. He meant no disparagement to the Gothic system when he expressed his belief that it never could have come to us but through the artistic darkness and barbarism of the middle ages—for none but men who knew nothing of Classic canons of art, and on whom Greek and Roman tradition had no authority, could have made so bold a departure from the architectural style which at the time was all but universal, as the Lombards and other Gothic tribes made in the sixth and following centuries. Reverence for their great predecessors would never have suffered Roman artists to take sufficient liberties with the proportions of the Greek ordinance for the creation of a style so different in spirit and principle of composition as the Gothic. We were indebted to an outburst of barbarism in the fifth century, which destroyed the civilisation of the ancient world and plunged Europe for ages in mental gloom, for the greatest system of architecture that had arisen since the Greek; and to the rise of a false prophet in the seventh, propagating his doctrines by the sword, and carrying desolation over the fairest countries of the globe, for another, which if not so great, was still more elegant and refined.

The author went into a critical examination of various minor styles, Romanesque and mixed, such as the Sicilian, Italian-Gothic, Moresco, Neapolitan, and others; and then entered into an account of the revival of ancient architecture, the first dawn of which was in the thirteenth century, and traced the course of the modern Italian stream of art through the great period of the Cinquecento to the present time. In conclusion he said he should not have given so much attention to the subject but for a conviction that a knowledge of the development and history of styles was greatly assisting, if not absolutely necessary, to a right understanding of the principles of architecture.

LATTICE GIRDER BRIDGE ON THE ST. GALLEN RAILWAY, SWITZERLAND.

(*With Engravings.*)

A variety of particulars and data relating to the principal bridge works constructed during the last few years on the railroads of Switzerland, were given in the last number (page 320) of this *Journal*. Among the bridges there referred to is one—the bridge over the Sitter at St. Gallen—which we think deserves special notice for its ingenuity of design and construction: we therefore give a more detailed account of it, with illustrations. From the general plan, Plate XXXIII., Fig. 1, it will be perceived that this bridge consists of four openings formed by three cast-iron piers, which are traversed by lattice girders, and approached from the right bank of the river by a stone bridge of two spans. The bridge of approach is 65 feet long between abutments, and its centre pier to the impost of the arches 40 feet high, whilst the level of the rails occupies an additional height of 23 feet. The form of both stone arches is semicircular, and they have each a clear span of 24 feet: the breadth is 13 feet.

The length of the iron bridge is 535·4 feet, and its height above the mean water-level of the Sitter 204·8 feet, English measure. The clear width of each of the two centre openings is 125·5 feet, whilst each of the extreme openings is only 119·4 feet wide. The total distance between abutments is 524·86 feet. The slope of the left bank of the river is very steep, so that for this side only a low abutment was required; whereas the opposite abutting pier is 81·5 feet high, and joined by the bridge of approach, which connects the larger bridge with the embankment.

This bridge, constructed to carry only one line of rails, was designed by M. Carl von Etzel, and executed under the superintendence of Messrs. A. Hartmann and L. Pestalozzi. It was commenced in October 1853, and completed in the year 1856.

The base of the piers is founded upon solid rock. The stone foundations or plinths of the piers are of the shape of an elongated octagon, and measure at their base 23 feet in width and 40 feet in length. At the height of 44 feet, where their width is reduced to 22 feet and their length to 38·8 feet, they receive the cast-iron piers, 157 feet in height, carrying the lattice girder bridge. The abutting pier of the right bank is formed by a block of masonry, 82·5 feet in height, 8 feet thick, 27 feet long at the base, and

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19 feet at the top, and strengthened at each side by a kind of buttress,—one constituting the abutment of the bridge of approach and the other the bearing of the lattice girder: the latter is 70·5 feet high by 16 feet wide, and projects at the base 8 feet and at the top 5·8 feet beyond the face of the abutting pier, as will be perceived from the side elevation, Fig. 3.

The most important as well as most novel feature of this structure is the cast-iron piers. Each pier is chiefly composed of a double framework, 10 feet apart from each other, 34·44 feet long at the foundations and 15·94 feet at the entablature. These longitudinal frame-connections of a trapezoidal outline are again braced together by two transverse frameworks of a similar construction, 14 feet apart from each other, 17·44 feet long at the bottom and 11·44 feet at the top. Each of these frame-connections is formed of 25 rows or divisions of smaller frames, which are—within the limits of the parallelopiped formed by a transverse horizontal section through the four main connections—of a rectangular form, but assume a trapezoidal shape where they project beyond these limits. These projecting frames form a kind of rib or buttress, in order to increase the extent of the base of the piers, and to impart additional strength for resisting forces acting laterally. The frames constituting the divisions of the main framework consist each of an exterior flange, 9½ inches wide by about 1 inch thick, and a central interior rib at right angles to the flange, from 7⅜ to 9½ inches deep and from 1 to 1¼ inch thick. The eight projecting legs or buttresses are stiffened by ribs of the ⌴ form, with a web of 1 foot wide and from 1 to 1¼ inch thick, and flanges projecting from 4¼ to 5½ inches. In order to brace the whole framework transversely together, cast-iron pieces in the shape of a St. Andrew's cross have been inserted every 12 feet. They are of the ⊥ shaped section, with ribs 7¼ by 1 inch thick. The fitting strips between the joints of the framework could not be shown, on account of the reduced scale at which the details are represented on the Plates: that such were however provided need hardly be mentioned, as well as that all joints were planed before being fitted together on the site of the bridge. The top of each pier is provided with a plain but tasteful entablature of cast-iron (Fig. 7), 6 feet in height, with eight projecting ribs, the intervals between which are filled in with trellis-work. On this entablature are bedded the two lattice girders of the bridge. The horizontal cross-section of the cast-iron piers is—at the base 998 square inches, and at the top 613 square inches.

The openings consist of two wrought-iron lattice girders, which carry wrought-iron transverse girders of a similar construction. Across these transverse girders are laid longitudinally sleepers of wood, to which the rails are fixed. The top flanges of the lattice girders are of the same section as the bottom flanges; they consist each of four rows of plates, and are 11 inches wide by 2⅝ inches thick. Fig. 8 shows a section of the girders, and Fig. 7 is an elevation of the trellis-work. The lattice bars are of flat iron, 6 inches wide by 0·6 inch thick; they intersect each other at seven different points, and form in this manner a series of rhomboidal openings, the horizontal diagonals of which measure 2·66 feet, and whose vertical diagonals are 3 feet deep. The connection of the lattice bars to the top and bottom flanges is effected by angle-iron 4¾ inches by 6 inches by ⅝ inch thick. The total depth of each girder is 12·81 feet.

The lattice girders are connected together over the piers, in the first place by four wrought-iron plates which cover and are riveted to the lattice bars, and in the second place by a casting screwed to the top flanges. This casting is contrived so as to receive either a flag-staff or a column for supporting lamps. At a distance of 5·7 feet from each end, additional stiffening bars, formed of angle-iron 4¼ by 4¼ by 0·6 inch thick, are riveted to the girders. The transverse girders connecting the two main girders, which are 14 feet apart, and support the longitudinal sleepers, are also of the lattice construction, as shown. The top flange of these girders is of deck-iron, and their bottom flanges are formed by two angle-irons 6 inches deep; the lattice bars are of flat iron 4⅛ inches wide; the diagonals of the openings—formed by their intersections, are 2·88 feet wide, and 2·28 feet deep. Additional strength is imparted to these girders by a transverse bracing of flat bars, which are fixed to their top and bottom flanges.

Figs. 5 and 6 represent the details of the bearing of the lattice girders on the abutments. The abutments carry each five sleepers of timber, to which is fixed a cast-iron bed plate. Between the latter and the bearing of each girder is interposed a wrought-iron frame with five rollers. The projecting flanges of this wrought-iron frame secure on the one part the guidance of the rollers on the bed-plate, and on the other embrace the bottom flanges of the girders. This arrangement is intended to admit of the contraction and expansion of the lattice girders due to variation of temperature. The roadway is formed by two longitudinal timbers, on which the rails are fixed by spikes. The space at each side of these timbers is filled up by planking.

The weight of the iron piers is,—

	Tons.
Cast-iron	902·92
Wrought-iron	31·472
Total	934·392

To this we have to add the weight of the iron superstructure, which is,

	Tons.
Cast-iron	10·93
Wrought-iron	330·22
Total	341·15

The weight of the superstructure amounts therefore to ·638 tons, (or about 12 cwt. 3 qr.) per foot run; the weight of the roadway, however, not being taken into account. The centre pier has cordingly to support a load of 125·5×12·75 cwt.=80 tons 1 cwt. 1 qr. Adding to this the weight of a train, say 100 tons, and weight of one pier=⅓ of 934·392 tons=311·464 tons, we have for ultimate weight which the pier has to support at its base about 492 tons. Taking the section at the base of the pier, as above stated, at 998 square inches, we have about 2·028 tons per square inch, which insures a great degree of safety.

The cost of this structure was

Foundations	£1374	15	6
Masonry	5992	8	9
Iron superstructure—Ironwork ...	10451	8	0
" " Scaffolding, &c. ...	1984	0	0
Iron piers—Ironwork	16351	0	0
Scaffolding	232	0	0
Total cost ...	£36,385	12	3

We have accordingly £23. 8*s*. 3*d*. for the expenses per foot run of the iron superstructure, and consequently for the

Average cost of the superstructure ...	£30	12	8	per ton.
" " piers	17	9	9	"

Reference to Engravings.

Plate XXXIII. Fig. 1. General plan, $\frac{1}{1000}$th real size.
Plate XXXII. Fig. 2. Elevation of base of pier.
" " Fig. 3. Side elevation of ditto.
" " Fig. 4. Sectional plan at *g h*.
" " Figs. 5, 6. Details of bearing of lattice girders.
Plate XXXIII. Fig. 7. Elevation of upper portion of pier and part of lattice girder.
" " Fig. 8. Transverse section of ditto at *ab*.

An Invention to save the Oil used in lubricating Car Axles.—The immense amount of oil used in lubricating the rolling stock of railroads makes it an object of no small importance to save it, and it affords a tempting field in which to test the skill of the inventor. The journal-box which is the subject of this article may not be successful, having yet to stand the test of thorough trial; but nevertheless it may serve to awaken thought and attract attention in other quarters which will ultimately be of service. The invention consists of a box in which the shaft is intended to rest; but instead of resting upon a smooth, stationary iron surface, the shaft rests upon a number of rollers which encircle it, and, as the shaft moves, chase each other around it. The principle is that of moving a heavy body upon a plane by placing it upon rollers, instead of attempting to slide it. Between the larger rollers upon which the weight of the shaft rest there are intermediate and smaller rollers, which perform the office of keeping the larger ones in their proper position. As the axle revolves, all the rollers travel with it in a given direction; and as all roll, and in no case slide, it is maintained that there is no friction, and no oil is necessary for lubrication. The lateral or end thrust of the car axle is received upon three globes placed in a cup, fitted for that purpose between the "box cap" and the end of the axle: in turning curves the lateral pressure is thus greatly reduced. We understand that this box is being placed upon some of our city railroads for trial.—*American Railroad Journal.*

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HEALTHY DWELLINGS, AND PREVAILING DEFECTS IN THE HOMES OF THE WORKING CLASSES.

By Henry Roberts, F.S.A.

(*Concluded from page* 329.)

The striking contrast which the homes of large masses of our working population present to all that is essential in a healthy dwelling, renders them not only a painful study but also a just cause for national humiliation. I have felt it to be such when endeavouring on the Continent to press attention to those sanitary ameliorations which are in all countries so greatly needed. It is true that England has taken the lead in associated practical efforts for the improvement of the dwellings of the labouring classes, and that, for several years past, individual efforts have been made by some of the most exalted in station and social position. Legislative measures have also been adopted with the same end in view; but these being chiefly of a permissive character, but little comparatively has been effected in producing any marked improvement in the domiciliary state of the masses of our working population in towns; if we except the state of the common lodging-houses, which, under the operation of a compulsory Act, have been very greatly improved.

On the state of the lower class of dwellings in our provincial towns we have the evidence of innumerable official reports. In one of them we learn that "at Leicester the worst houses are to be found in the old quarters of the town; they are the habitations of the working classes and the poor, and are faulty both in arrangement and structure. For instance, there are eleven houses of one room each, at first used as pigsties, but, the speculation failing, they were converted into dwellings, each 14 feet by 10 feet, and 8 ft. 6 in. high, with an average of five persons in each room." Of Swansea we know, on the authority of the mayor, that in a sanitary survey of the epidemic districts there were found in five consecutive cottages in one street, seventeen, thirteen, eight, ten, and twelve inhabitants; each house had two sleeping apartments, the largest 10 feet by 8 feet, the other only 8 feet by 6 feet, giving a total of sixty inhabitants shut up in ten rooms not too large for the requirements of ten persons; and, as a necessary consequence, some form of disease was always present. In the town of Hertford, out of 294 courtyards or alleys, close and confined, without entries from the main street, and mostly terminated by a *cul-de-sac*, only 32 have any outlets at the back made for ventilation. Referring to such places, it has been remarked by Mr. Rawlinson, that "In the towns formerly occupied by an agricultural population, and afterwards adapted to receive an increase of artisans and manufactories, it is universally the custom to convert old and decayed manor-houses or other large buildings of any extent into a number of dwellings; but the requisite attention to sewage, ventilation, and other accommodation demanded by the increased number of inmates, seems quite forgotten, and they are left to make the best arrangements they can for themselves, when in fact the most careful supervision should be exercised by the proprietors." In another report the same gentleman, after naming ten northern towns, says, "There are blocks of houses and tenements which no remedial measures can ever make healthy dwellings, because the construction prevents free ventilation, and the sun can never shine within the crowded area, or even the light of day break the continuous night, in which many of the poor at present exist."

The prevailing sanitary defects in the homes of our rural labouring population have yet to be noticed. Although much has lately been done by many landowners to improve the cottages on their estates—and instances might be named in which a sense of duty in this respect has been manifested by a princely, and at the same time judicious, expenditure—it is a lamentable fact, that there are but few counties where there are not a great many cottages around which the external air may be good and circulate freely, but their aspect is such that the sun's rays never enter the dwelling, or the site is remote from good water, or the drainage defective. The walls, the roof, or the floor, perhaps all of them, admit the external humidity. The windows are badly constructed for the purposes of light and ventilation. The rooms are very low and too few in number for a family; indeed it is rare to find more than one or two bedrooms in an old cottage, although three are evidently indispensable to the health and moral habits of a family with children of both sexes.

In some instances which have fallen under my own observation I regret to say that the want of judgment in the selection of plans has led to the building of cottages, more particularly in the neighbourhood of manufacturing towns, which by no means combine all the requisites of a healthy dwelling. In other cases an unnecessarily heavy expenditure has been incurred, whereby an impression is created that even under favourable circumstances the moderate return of 3½ or 4 per cent. clear, cannot be obtained from well-built cottage property.

With respect to the important question of pecuniary return for capital invested in the improvements of the dwellings of the labouring classes, I may quote the words of the Duke of Bedford, and other distinguished landowners, who have placed its bearings in regard to the owners of land in their true aspect, and show that from 4 to 5 per cent. clear of expenses, and in some instances a higher rate, has been realised in towns from newly-built improved dwellings, in a sufficient number of instances to prove that, with the exercise of a sound discretion and careful management, a return may be obtained which is about equal in percentage to the average profits of the nine great railways diverging from the metropolis.

One important result which would inevitably follow the legal enforcement of a good sanitary state in all dwellings let in apartments to pay a low weekly rent, must be that those who now obtain a large profit out of the necessities of the poor would be forced either to make the much-needed improvements of the dwellings themselves, or to part with them on equitable terms to those who might be willing to make the necessary outlay in anticipation of a reasonable but not extravagant return. At present such property, if sought after, can only very occasionally be obtained at a price which, with the heavy expenses of repairs and the maintenance of old buildings, will yield a fair rate of interest. It is gratifying to know that the results of all the efforts made to improve the homes of the working classes have, in regard to the occupiers, been most encouraging.

It may be useful to recapitulate briefly the various means through the use of which the dwellings of our working population can be rendered "healthy homes." They may be ranged under the three heads of—government measures; the action of public bodies, of the employers of labour, as well as of voluntary associations; and personal influence.

In England, where every man's house is said to be his castle, legislative interference can only be anticipated to a very limited extent, beyond the enactment of general sanitary laws, and those which are strictly of a permissive character, or calculated to favour the action of individuals and of associations in providing improved dwellings. A step further in advance—one which has proved most successful—has been taken in the regulation of common lodging-houses; and not until the same principle is applied to the enforcing of a good sanitary condition with suitable arrangements in all tenements in towns and populous neighbourhoods, let at low weekly rents, can it be anticipated that the miserable dens in which large masses of our population at present herd, will be cleared of their filth, and rendered fit for the occupation of human beings. Within the jurisdiction of the corporation authorities of the City of London such a power was conferred in 1851, and is discreetly exercised under the supervision of the medical officer of health, to the great benefit of the poor and a marked diminution in the returns of mortality, which have fallen since that date from 25 to 23 in 1000. By a standing order of the House of Lords, provision has been made for ascertaining the necessity of enforcing the construction of suitable dwellings for the working classes, in lieu of such as may be demolished under powers granted by parliament for the carrying out of public improvements or the works of large companies, such as railways, docks, &c. The non-enforcement of such an obligation has led to incalculable misery and evils in our own metropolis, as well as in that of a neighbouring country. Legislative interference is also much needed to provide a remedy for the evils arising out of the selfish system pursued in some "close parishes," of pulling down cottages, in order to obtain relief from a burden which is thereby thrown on a neighbouring parish. The building of small houses on undrained ground, and without proper sanitary arrangements, should, as a fruitful source of sickness, and consequent expense to the public, be entirely interdicted.

Public bodies, including many departments of government, railway, and other commercial companies, as well as the regular employers of working people generally, whether they be agriculturists, manufacturers, owners of mines or quarries, have it in

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their power greatly to promote the well-being of those whom they employ, by caring for their domiciliary condition, and by either providing suitable dwellings for them—which may generally be done with ample security as to the cost—or by aiding them to form among themselves well-constituted associations for the carrying out of that object. In other instances existing dwellings may, as we have seen, be greatly improved at a moderate cost. The construction of model dwellings by associations formed for that purpose, as well as the renovation of old houses, have proved in some places of great value as an experimental and pioneering movement, irrespective of the immediate benefits conferred on their occupants and the immediate neighbourhood. The pecuniary return, of necessity, greatly depends on the judgment and care exercised in the selection of sites and in the arrangement of plans, as well as on watchful and economical management.

The practical results of the personal interest taken in this object by the Prince Consort, in connection with the Great Exhibition of 1851, have been manifested in several instances by the providing accommodation for married soldiers, the want of which led the late Duke of Wellington to object to the placing of the model houses in the barrack-yard, lest they should cause dissatisfaction in the army. During the present session of parliament £30,000 have been voted for this object. Amongst many examples of houses built after the general plan of those in the Exhibition, is an entire street near the Shadwell station of the Blackwall Railway, built by Mr. W. E. Hilliard, of Gray's-inn, who has the satisfaction of having replaced a miserable range of dwellings with "healthy homes" for 112 families, which return him between 6 and 7 per cent. clear on the outlay of about £14,000.

ARCHITECTURAL DRAWING.*

By W. Burges.

In selecting the subject of my paper, it is with some misgiving that I have chosen that of Architectural Drawing. I feel that I ought rather to have selected one of those stock subjects, viz., architectural colour and mosaic, on which so much is to be said, but which we have seldom or never the means of putting into practice, either from the disinclination of our clients, as in painting, or from the want of materials and special artists, as in mosaic. In the meanwhile, whenever we do get the opportunity, the result is generally a failure, partly because no rules will ever teach a man the value of one tone of colour as compared with another, and partly because we require in this case to be taught by repeated failures as to what combinations of colour look well and what look ill. Under these circumstances, therefore, it has struck me that it might be more useful to bring together a few notices of a much less ambitious branch of the arts, but which however is of the most vital importance to architects, inasmuch as it exercises more or less influence upon the design of the building itself: and we all know that, although the building is but the skeleton for the addition of painting and sculpture, still, if that skeleton be bad or deformed, no satisfactory result can ever arise, even with all the painting and sculpture in the world. I venture to assert that the manner in which a man draws does and must affect the nature of his design more or less. Thus, if he uses strong, thick lines, he will, in all probability, be induced to make his design massive and simple, and not give way to the vanities of crockets and pinnacles, because he will find that he has hardly got space to get them in. He likewise sees his design in its most severe and unfavourable light, and ten to one the building will turn out much better than the drawing, to the advantage of every one concerned. If, however, the architect draws in a moderately thick line, and puts in the stone joints and etches the walls—I am now speaking of elevations, &c.—he simply deceives not only his client (which is partly allowable) but, still worse, himself, for the building is almost sure to come out worse than the drawing,—the joints, roughnesses, &c., not, of course, showing in new work.

As to the third style of drawing, with very fine hair-like lines, relieved by what is termed back lining, whereby small fillets are made to look like hollows, and hollows like fillets; this style is scarcely worth mentioning, for it means nothing, and hardly anybody employs it in the present day.

I believe nothing whatever is known of the architectural drawings of the Greeks and Romans. The Lapides Capitolini, containing a plan of Rome, are simply inscribed on marble, and formed anciently part of the pavement of the temple of Romulus and Remus; and the light and beautiful architecture painted on the walls of Pompeii was never, that I know of, resolved into real materials. Our series of drawings then opens with the plan of the Monastery of St. Gall, now preserved in the library of that establishment. It was first published by Keller, at Zurich, in 1844, and republished two-fifths the real size, in the 'Archæological Journal,' p. 87, vol. v., with a most excellent notice by Prof. Willis. The plan, which is drawn in thin red lines upon a large sheet of parchment, with inscriptions all over it, showing the uses of the different parts of the building, was sent, as one of the said inscriptions informs us, for the use of the Abbot Gospertus (who began to rebuild the church and monastery in 829), by some anonymous friend, who is supposed with some reason to have been Eginhard, the son-in-law of Charlemagne, who held the office of prefect of the royal buildings. However this may be, the plan presents us with a very complete monastery, with its great church and accompanying buildings. The red line not only serves to mark the external and party walls, but also to indicate the furniture, such as benches, tables, stoves, &c., requisite to each building. The plan, as Professor Willis very properly remarks, is not done to scale, but certain figured measurements enable us to form some idea of the size of the buildings. The church would appear to have been a most noble structure, with two apses and three paradises or semicircular walks. The western one was further enriched with two circular towers. The winding stairs of these latter are shown as gradually winding round from the circumference to the centre, like a section of a snail-shell. It is doubtful whether a common winding staircase is thus represented, or whether it was really an inclined plane, which went from the circumference to the centre, and so on to an upper chamber, where there was an altar, in the one case dedicated to St. Michael, and the other to St. Gabriel: there would, supposing the latter supposition to be correct, be room to hang the bells in the space between the newel and circumference in the upper part of the tower. The ornamental finial at the top is shown on plan as finishing the newel.

The arches of the cloisters and the crosses of the altars are shown in elevation on their respective places on the plans, a mode which still obtains in Turkey at the present day, even among the distinguished native architects who have the honour of working for his Imperial Majesty the Sultan, so little have things changed in the East. Another peculiarity in this St. Gall plan is, that sundry squares are drawn in the middle of courtyards and of buildings. These, as Professor Willis suggests, might be either indications of the Classic atrium with its uncovered impluvium, or a sort of upper lantern rising above the roof and giving light by means of clerestory windows. Both these explanations are very feasible, and both probably were intended in the original. Lastly, Eginhard, or whoever was the architect, wrote certain explanations in Latin verses on various parts of the drawing. Fancy that most matter-of-fact production, a modern plan, ornamented with metrical directions to the builder!

The next drawings to be noticed are those incidental pieces of architecture which occur in the Anglo-Saxon MSS. in which the British Museum is so rich. It is true that they are generally ill-drawn, but still they show us enough to enable us to draw very valuable conclusions as to what Anglo-Saxon architecture really was, and to refute the generally conceived idea that both architecture and history began in England exactly in the year 1066. Mr. Wright has contributed a most interesting paper on this subject in the 'Transactions of the Archæological Institute,' vol. i. In it he shows that the triangular arches and the baluster shafts, which are now recognised as Anglo-Saxon features, occur equally with representations of domes and carved capitals, pinnacles (not crocketed), and iron-work, which antiquaries are generally unwilling to acknowledge as belonging to the time before the Conquest; as if the countrymen of Alfred and Edgar, both great and powerful kings, should have been unable to carve a capital or use a chisel, when they were renowned all over the world for their manuscripts, jewellery, and embroidery.

I suspect the fact is, that the history of architecture has hitherto been written in far too scientific a manner; and because the art exhibits a general progress and decline, people have believed that sundry processes were unknown at certain periods, when in fact almost all the essentials of building have remained the same throughout all ages. Thus, because Gervase says that the work

* From a paper read at the Royal Institute of British Architects.

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of the old Cathedral of Canterbury was done with an axe and the new with a chisel, we are to suppose that the Saxons had no chisels and no carved ornaments.* Now the MSS. distinctly show us elaborate capitals which must have been done with a chisel, and no one can for a moment imagine that so useful and obvious an instrument could ever have been lost, even in the most barbarous countries, much less so among the civilised Anglo-Saxons. We owe also to Mr. Wright the first doubt as to the date of Waltham Abbey Church. Hitherto most antiquarians believed it to be of the date of Henry I.—first of all, because it was like the architecture of that time; second, because the two queens of that king were great benefactors to the establishment; and third (here was the rub), because it was more ornamented than any known contemporary Norman or Saxon building. As if Harold, the highest and most powerful man in England, could not have given orders for a rich building to be erected, or had not the funds to carry it out. I do not deny that he might have employed foreign workmen, but it by no means follows that these foreign workmen must have come from Normandy. Harold and his family were very properly anti-Norman, and it is just as likely that he got his workmen from Flanders, or some other part of the continent, as from Normandy.

The next document I shall bring forward is a view of the Church and Monastery of Canterbury, contained in the magnificently illuminated Psalter of Eadwin, which is now preserved in Trinity College, Cambridge. This very curious drawing, which is made to do duty both as plan and elevation, has likewise received the elucidations of Prof. Willis, to whom I may venture to say the literature and some parts of the practice of our art owe more than to anyone else. The way in which the plan and perspective are made to co-exist is by making a vanishing point in the centre of each court, so that there are three or four of these vanishing points in the drawing. The two towers which we saw in the plan of St. Gall here re-appear, although in different positions. All the watercourses and drains are shown, and upon the whole, considering the very original perspective, it may be pronounced to be an accurate drawing; indeed, Prof. Willis tells us that, wherever a building is shown on this plan, Romanesque work is more or less found at the present day at Canterbury. I have not been able to see the original of this drawing, but the notice in the 'Vetusta Monumenta,' where it is engraved, assures us it is coloured. As a drawing it is curious, as showing the complete development of the practice of drawing elevations upon plans, as at St. Gall. I think, however, that we must consider this drawing of Canterbury more in the light of a survey for the purpose of showing the system of watercourses, than as a document to be worked from. In all probability such documents would not be very common, and when the work was done the erasing knife of the writer would be brought into use, and the parchment or vellum, which was very valuable in those days—and which by the way is not very cheap in these—would receive a new employment. That this was the case we know from the discovery made by MM. Varin and Didron in 1838, of the design for the west-end of a cathedral, besides several details, under the writing of a MS. which contained a list of the deceased members of the chapter of the cathedral of Rheims. Now the last entry is 1270, and the drawings were executed in all probability some time before. They have, according to M. Didron's account in the 'Annales,' vol. v., been first sponged out and then scraped over to obliterate the lines, and finally cut into leaves. However, enough remained to enable M. Didron, assisted by the late M. Lassus, to produce engravings of several portions, which will also be found in the same volume of the 'Annales.' M. Didron assures me that the lines are very thin, which is not to be wondered at, considering the treatment they have undergone.

The principal composition shows a façade for the west end of a church, with the usual three portails and the somewhat unusual feature of a large window above. It is either an unfinished production, or one for the use of the architect and his work-people alone, for as little as possible is shown. Thus, only two or three crockets are shown at one side of the great pediments, and no ornament or figure is shown in the voussoir; the left-hand corner is indeed more worked up, but the artist has made up for it by showing nothing at all on the right. The whole composition appears to me to want somewhat of severity, and I hope that it was sponged out and never executed, on that account. Another plate shows part of what M. Didron thinks is another portail, but which might possibly represent the return angle of the former drawing. It is remarkable if really a portail, as showing the outer plan of the centre door as filled with tracery. If this be really the case it shows an arrangement somewhat similar to what obtained in the west front of the now destroyed church of St. Nicaise, at Rheims. M. Didron thinks that the architect, being hard up for room, drew in the tracery of the window, but to a different scale to what the portal was drawn to. But if this were the case, a window would hardly have its centre light twice as broad as its side ones, which this has. Below this portail are three pieces of ornament, each drawn in between borders composed of six lines each. What these six lines mean I am totally unable to decide, unless they represent, in a sort of shading, the rounded edges of the bowtels on either side of the great hollow in which they are placed. But I certainly cannot agree with M. Didron's suggestion, that they may be the lines of the musical scale, and as the outer parts of the ornament are occasionally drawn upon them, and of course go up and down, so we have a sort of architectural music.

Villard de Honnecourt is the next on the list, the fac-similes of whose sketch-book are now in the hands of everybody. So much has been said and written concerning these drawings, that I shall very much curtail my description of them, which would otherwise have been long, considering that these are the most perfect, and the largest collection, of the drawings of the middle ages that have come down to us. And, first of all, I must be allowed to claim Villard for our profession, as some attempts have been made to hand him over to the sculptors and painters, because, forsooth, he drew the figure too well and too frequently. There is one fact however which completely, as far as I see, upsets this theory, and that is this: the tendency of an artist, either painter, or sculptor, or architect, would be to sketch details which would come in useful to him;—thus, the painter and sculptor would draw parts of the human body, bits of costume, anatomy, &c.; while the architect, on the contrary, would draw moulding, capitals, foliage, &c. Now, in the sketches under consideration we do find the capitals, foliage, and mouldings, but we do not find studies of hands, of feet, of anatomy, &c.; but on the contrary, there are a number of problems, which could only be useful to a man engaged in actual building. As regards the drawing itself, the sketch was first made with a leaden or silver pencil, either of which would perfectly mark on the vellum; if the subject were an architectural one, the straight lines were ruled and the circles put in with a compass, one end of which had a leaden point; these lines were afterwards gone over with a blackish-brown ink, by means of the hand alone, no instrument being employed. Upon looking again at this MS. two months ago, I was struck more than ever by the extreme precision of the touch,—there is no faltering or wavering, but the line is just as thick and as firm where it ends as where it begins. Again, in drawing things in small, mouldings and foliage become simplified, so as not to break up the breadth of the composition. Clearness is got by blacking hollows where they occur, and the grounds of ornament, such as capitals, &c. The walls of plans however are not etched, and we shall find this practice obtaining even in Thorpes' time, the majority of whose plans are not etched, although not devoid of colour. One would imagine that Villard might have etched them up with his leaden point, as he often did his drapery; but nothing of the kind occurs. Another peculiarity of our architect was, that when he copied any executed work, he copied it not as he saw it, but with variations of his own, and as he would execute it himself. Thus, the window at Chartres is considerably altered in order to get more space for light, while that at Lausanne is so much so that it can hardly be recognised. But with all his peculiarities, Villard presents us with a decidedly good style of drawing, and which, it strikes me, might eventually be developed into something much better than that in use of late years. I mean, that we should join our improved knowledge of perspective and of the figure, to the energy, simplicity, and firmness of our *confrère* of the thirteenth century.

The fourteenth century affords us the drawings of the Cathedral of Cologne. These I saw some ten years ago, but as far as I remember, I was told that the originals were in the architect's office, and that what I saw were only copies. It is very true that they, besides several others, have been published, both in Germany and France; but I must confess that I should be sorry to deduce any theories as to thickness of line from the fac-similes of the Germans, who have an abominable mode of pub-

* See Willis's 'History of Canterbury Cathedral.' It is surprising that this book has not been more popular with the profession: it is the history of the building of a chancel, or rather of the choir of a chancel, during the very best period of art.

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lishing almost everything in the finest possible lines, exactly like Pugin's 'Specimens,' and other works of that period, thereby utterly depriving them of all vigour, and producing a very false impression.

The fifteenth century being nearer our own time, presents us, as might have been expected, with a greater number of drawings. First, we owe to Prof. Willis the explanation of the legends attached to the section of the mouldings from the door of the church of St. Stephen's, Bristol, made by William of Worcester in his Itinerary, preserved in Corpus Christi College at Cambridge. But the most interesting to us as Englishmen are those drawings for King's College, Cambridge, now in the Cottonian Collection at the British Museum. The first of these shows the east and north sides of the chapel in perspective—*i. e.*, the north side is drawn parallel to the horizon, almost in elevation, while the lines of the eastern go to a vanishing point. The drawing is partially coloured, and is especially curious as showing a small half-timbered building at the eastern end, with a flèche containing a clock-face. The details of the architecture are very well made out, and it has ruled lines like a modern drawing. No figures are shown in the niches, and the rain-water is carried off by regular pipes as in the present day. Curiously enough, similar leaden pipes are to be found in those parts of the Cathedral of Beauvais erected at the end of the fifteenth century, but in this latter case they are elaborately tinted with powderings of fleur-de-lis, &c. Although this drawing has the look of having been subject to a good deal of wear and tear, and just as if it had really been used by workmen, I am afraid that its general appearance has the look rather of the sixteenth than of the fifteenth century. Another drawing shows us the tower intended to have been erected close to the same building. As an architectural composition it is of no real value, having several stages with a small window in each, and an octagonal buttress at each angle, which buttresses finish in spirelets. The drawing is executed in ruled black lines, and has a wash of blue colour, more or less deep, all over the building. The hollows of the mouldings are not blackened in, but etched, which is the next best thing, although rather a dangerous one, for the contractor on one occasion actually mistook the etched hollows in a drawing I gave him for dog-teeth, and estimated them as such,—of course, when the amount had to be deducted from the estimate, the dog-tooth ornament was not allowed too much for. I should mention that this drawing of the tower of King's College is in perspective, although of a very unsatisfactory kind; for among other things, the whole of the four spires find themselves at the same level at the top of the drawing.

Another design of about the same period is that for a gallery for Henry VIII. This likewise is in perspective, and runs diagonally across the page. It is drawn with the free hand in black ink or pigment, but one or two of the longest lines have been ruled; it is likewise shaded up in black, and locally coloured with thin washes, like those I shall presently notice in Albert Durer's works. It is a very careless drawing, and the style is a sort of bad Germanised Renaissance, with baluster columns. A later drawing is contained in the same collection, the date of which would probably bring us to Edward VI. or Mary; it is the façade of a house, almost in what is now called the Italian style, but with Renaissance details; the perspective is very fair, the vanishing point being in the middle of the building, so as to show the projecting wings and the external staircases in perspective. The composition also is by no means deficient in picturesqueness; we can hardly praise the colouring, which, with partial shading in black or gray, presents us with a bright body-colour cobalt roof, and bright vermilion casements to the windows.

(*To be concluded in our next.*)

REVIEWS.

A Practical Treatise on the Construction of the Turbine or Horizontal Water-wheel. By WILLIAM CULLEN, Engineer.—London: E. and F. N. Spon. 1860.

THE adoption of the turbine as a prime-mover is still in its infancy in this country, therefore whatever contribution on this interesting subject, however small, may be added to the existing stock of information for practical men, cannot fail to be welcome. Theoretically this class of water-wheel has been treated by several writers on Applied Mechanics, amongst whom we may mention Prof. Rankine, who has in his late works thrown considerable light upon the subject; but notwithstanding this, very little has been said which would come, strictly speaking, within the reach of the practical engineer and millwright. This deficiency, as well as the limited application of reaction water-wheels and turbines in Great Britain, and particularly in England, may to a great extent be attributed to the abundance of native coal: the consequent introduction and rapid progress of steam-engines having almost entirely supplanted motors of any other description. It is however to be hoped, that when the real advantages of this efficient and economical water-wheel are correctly understood, it will be more generally adopted.

Having remarked that a work explaining the principles of action and the practical construction and application of turbines is still a desideratum, let us see how far the book before us supplies this deficiency. Mr. Cullen sets out by explaining his motives for appearing as an author, and gives an account of two journeys to France with the object of collecting practical information on the subject in view. After having at some length detailed his reception, disappointment, and final success in obtaining the sought-for information, he goes on to enumerate the different descriptions of turbines in use, and their advantages over the ordinary vertical water-wheel, which he has done in a rather brief, but intelligible manner. We should have been better pleased had Mr. Cullen dwelt a little longer on this section of his book, and explained more than he has done the action of the water at different stages of its flow through the guide-blades and buckets: a more distinct classification of the different turbines and reaction water-wheels would also have been very acceptable, instead of a mere *enumeration* of their characteristics with reference to their inventors. After this the author proceeds to describe the various plates which illustrate his treatise. In the first place he furnishes a sectional elevation of a turbine constructed by M. Fourneyron, for the flour mill at St. Maur, France, with a plan showing the relative position and configuration of the directing curves or guide-blades and the buckets of the wheel, the curvature of which is given at a large scale on plate 4. On plate 2 we find a turbine, designed likewise by M. Fourneyron, for a spinning mill at St. Blazien, in the Black Forest of Baden. This turbine works with an enormous water-fall of 354 feet, and although only 27 inches in diameter, utilises an effect equal to 70 horse-power. Plate 3 exhibits a segment of the wheel at St. Blazien at full size, and also a method of delineating the curve of the buckets according to M. Fourneyron's plan: whether this method is identical with that used by M. Fourneyron is a question that has to be ascertained, as Mr. Cullen himself in a previous part of his book asserts M. Fourneyron's disinclination to communicate his plans. Plate 5 contains an illustration of setting out the curves of the buckets, when constructed of malleable iron; and plate 6 represents a segment of a wheel under similar conditions, with their buckets and guide-blades cast in one piece, the latter being here formed by circular arcs. As the last example of which the writer gives an illustration we have to notice a turbine designed by himself, and differing from those usually constructed by M. Fourneyron, by its having the impelling water conducted into it from the underside, similar to the arrangement of Whitelaw's reaction water-wheel, with the modification moreover of placing the step for the vertical shaft above the level of the buckets, in order to facilitate the lubrication of the pivot. This last advantage would, in this case however, be lost, should the wheel be working much below the level of the tail-race.

In concluding his book Mr. Cullen gives a series of rules—which are to a certain extent empirical—for proportioning the different parts of the turbine, but omits entirely to bring forward the elements from which he derived them. Although the author intended the results of his researches especially for artizans and operative millwrights, we still deem it of sufficient importance that the author of a *Treatise on the Turbine* should acquaint the reader at least with these elements, which would tend only the more to accomplish his wishes, *i. e.* to familiarise the reader with the principles regulating the action and the effect of the turbine. As it is the reader must, in availing himself of these rules, work still in the dark, and take all things for granted, unless he is a theorist, and possessed of sufficient knowledge to follow up the application of the principle and its effects. Nevertheless, great credit is due to Mr. Cullen, for his praiseworthy effort to supply useful information on this

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important and hitherto much neglected subject, and to meet the requirements of the practical man. His treatise, though not in every respect so complete as might be desired, contains some valuable information on the subject of turbines, more especially on the setting out of the curves for the directing blades and buckets, which has not, we believe, been published before in this country.

We quite concur with the author as to the advantages to be derived from the more general introduction of these water-wheels; and, considering that their first application is much cheaper, their weight much less, and the space occupied by them much smaller, than that required for any other water-wheel; that they are alike efficient under high as well as under low falls of water, and especially applicable in those cases where the fall exceeds a height of 30 feet; further, that they work equally well under water, with no difference in effect; that on account of the rapidity of their revolution they may be directly attached to any machinery to be worked at a great speed, thereby rendering the intervention of all multiplying gear unnecessary; and finally, that they realise a useful effect from 60 to 75 per cent. when used under the falls for which they were designed,—we cannot but express surprise that the attention of mechanical engineers has not been earlier directed to the subject.

The British Almanack for 1861;—*and, The Companion to the Almanack.*—London: Knight and Co.

THE volume just issued for the ensuing year is in no degree inferior to preceding ones, either as regards the variety of information it contains, or the succinct yet clear method in which it is presented. In certain particulars, indeed, it is an almanack *per se*, and will maintain its place on the library shelf as a standard work when others of more pretension and ambitious exterior are comparatively forgotten. Upon the ordinary contents of an almanack it is needless to dilate: suffice it to say that all the essentials are contained in that before us, while the really valuable part occupies the greater portion of the book, and consists of matter collected with the utmost care and judgment, and which we seek for in vain elsewhere. Thus, in the body of the volume we find a very complete list of the principal educational schools throughout the United Kingdom, with the names of the several professors and other officers connected with each; while in the 'Companion to the Almanack,' which has now reached its thirty-fourth year, we are treated as heretofore to a well-arranged digest of information on subjects of mathematics, natural philosophy, natural history, chronology, geography, fine arts, public economy, the legislature, statistics, public improvements, &c. The great metropolitan question of Thames embankment receives due consideration, and the interest of the subject is greatly enhanced by the copious historical evidence with which the essay is introduced, ranging from the years 1666 to 1855, since which time, as is truly remarked, very little that is really new has been brought forward. A few words are then offered concerning the chief projects brought before the committee during the present year, and the several proposals of Messrs. Fowler, Lionel Gisborne, Sewell, Edmeston, Bird, Bidder, Page, and Thwaites, are briefly stated, concluding with the decision ultimately arrived at, in the form of the eight following resolutions:—

"'1. That the embankment of the north side of the Thames, from Westminster-bridge to or nearly to Southwark-bridge, would afford a desirable mode of improving the banks and bed of the river, and facilitate the construction of the low-level sewer along the foreshore; while a roadway on the embankment would greatly relieve the crowded thoroughfares.

2. That by the construction of docks inside the embankment wall, wharfingers and other persons engaged in business along the river would, in most cases, derive increased facilities for conducting their various trades and occupations.

3. That the statements made to the committee with regard to the probable cost of the proposed embankment vary considerably, ranging from a minimum of £400,000 to a maximum of £1,500,000, according to the nature and extent of the plan; but these estimates include the cost of the low-level sewer; and there is reason to expect that a large proportion of the total first cost would be repaid by works of a productive character.

4. That as in 1861 the 8*d.* and 1*d.* duties upon coal, and the ½*d.* duty upon wine, which were imposed and continued by Parliament for the purpose of public improvements in the metropolis, will cease; your committee recommend that they be renewed for a limited period, and that the whole or part of the cost of the Thames embankment be made a first charge upon them.

5. That the legislature having already entrusted to the Metropolitan Board of Works the main drainage of the metropolis, and armed them with power to deal with the foreshore of the river in connection therewith, your committee recommend that the construction of the embankment be also confided to them.

6. That for this purpose your committee suggest that the above-mentioned dues be placed at the disposal of that board for a limited period; and that a guarantee of the imperial treasury be likewise afforded them, according to the provisions contained in the 21 & 22 Vict. c. 104 § 6.

7. That your committee are of opinion that it would be most difficult to estimate, before the works are completed, the amount of damage that might be occasioned; they therefore recommend that power be given to ascertain, after the completion of the works, the amount of compensation that may be due.

8. That while your committee consider the embankment of the south side of the Thames to form a necessary part of any complete scheme for the improvement of the river and the metropolis, yet it is of less urgent necessity than that of the northern side.'

Thus the matter now stands: and it remains to be seen whether the session of 1861 will give legislative sanction to any mode of solving this vexed question. The committee mention no one engineer, and recommend no one plan by name. They simply speak favourably of *an* embankment on the north shore, within certain limits, having a roadway on it, a low-level sewer under it, and docks within it; they recommend that the Metropolitan Board of Works shall execute it, and the coal-tax pay for it; and they make light of the wharfingers' opposition, by proposing to defer any questions of compensation until after the works are executed. No joint-stock company is recommended, and no embankment railway mentioned. It is understood that at the present time (Nov. 1860) the government and the Metropolitan Board of Works are in communication, to agree upon the details of a measure to be brought before Parliament on this subject in 1861."

The next subject discussed is the management of our "Crowded Streets," embodying a large amount of statistical information bearing upon that intricate question, and a curious opinion is quoted, viz., that "if fifteen minutes are occupied in going where ten minutes would otherwise suffice, the carriers, wharfingers, wholesale dealers, omnibus and cab owners of the metropolis, lose £100,000 a year by the crowded state of the streets." In the way of remedies the following are dwelt upon:—"1. To construct new wide streets, by pulling down masses of poor and crowded dwellings. 2. To intersect the metropolis with railways. 3. To run steam passenger-carriages on the common roads. 4. To lay down horse-tramways."

"Ragged, Industrial, and Reformatory Schools" forms a fertile theme, yet does not exhaust the subject; while the pros and cons of the South Kensington Museum are treated of at still greater length, in a broad survey of the several collections it embraces, with a view to define their relative value and general purpose. The value of the collections entrusted from time to time to the exhibition, *on loan*, is remarked upon, as well as that of the "circulating collection" (as it is termed), which is formed of specimens specially adapted for lending to provincial towns, so as in a still wider sphere to extend its educational training. The plan is said by Mr. Cole to be a "perfect success," and the witnesses from the towns in which these circulating collections have been exhibited bore ample testimony before the House of Commons' Committee to the service rendered by them, and their appreciation by workmen as well as the general public. As regards the "collective value" of the Museum, we read as follows:—

"Regarding impartially each collection on its individual merits, there can be little question that each is calculated to meet a public requirement, and that, due allowance being made for the shortness of time that has elapsed since its commencement, and the limited means at command, each has been, speaking generally, formed judiciously and with a proper regard to its relative importance. But when we come to look at the Museum as a whole, we must speak of it with more reserve. The 'comprehensiveness' of the Museum has been sometimes referred to as a merit. To us, what is called its comprehensiveness appears to be its grand fault. It strives to include too much within its boundaries. Nothing, it seems to us, has been more clearly established by experience and by argument, with reference to great public museums, than that they best accomplish their purpose in proportion as they are confined to some one distinct and well-defined department of knowledge; within which, indeed, they cannot be too comprehensive in their grasp. But no museum can approximate to universality of aim without injury to itself and to its visitors. The additions which every day would bring to its several collections, would indeed render its collective magnitude ever more and more impressive; but then every accession would tend to render it less useful to the student, more bewildering to visitors, and to place it more beyond the reach of effective general supervision, and the compass of any reasonable building: to bring it, in a word, nearer to the almost inextricable

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confusion and clashing of interests which are doing so much to abridge the usefulness of the British Museum.

The South Kensington Museum is as yet far from this condition. Its several collections are all within manageable limits, and though at present sadly cramped for room, will find ample space in the proposed new buildings. But they already present a confused aspect to the visitor; and if *all* the collections are retained, and, as seems to be shadowed forth, others be added, and all go on increasing at the constantly accelerating rate at which public collections almost always proceed, it is not difficult to see, that even the spacious palace shown in the architect's plans will, within no distant period, be found insufficient: whilst in any case there is the evil of the visitor's attention being distracted, and his mind wearied, among the multiplicity of disconnected, and often discordant, collections. It may, indeed, be a popular resort, but its educational value will be but little for the mass of visitors. To us it seems that the present juncture, when an important extension of the building is about to be made, is one that renders it especially desirable that the question should be considered, and, if possible, determined,—What is to be the permanent character, and what the scope, of the South Kensington Museum? But this question was left wholly untouched by the recent Committee of Inquiry. The South Kensington Museum is, as it at present stands, a museum of ——? We fancy it would puzzle any ordinary visitor to say of what. The only central idea that would give unity to the miscellany of collections, is that which would be conveyed if its title were 'The Museum of the Science and Art Department of the Committee of Council of Education;" but then, with all its multifarious contents, the museum would be too palpably inadequate as an illustration of the functions of that body, whilst it would appear ridiculous to call it by the shorter title of the Museum of Science and Art.

The Museum now consists of three clearly distinct sections: Fine Art—Useful Art—Science. But the science so called is anything but scientific. In any view it has but a chance look. The Museum of Animal Products might point to the connection of science with manufactures; but then for vegetable products you must go to Kew; for mineral to Jermyn-street. Both that and the Food Collection would seem to be at South Kensington, because South Kensington was supposed to have an elasticity of constitution that allowed it to take whatever was offered to it. The Educational Museum is apparently here for a similar reason, though there is just so much fitness in the locality as can be imparted by the circumstance that South Kensington is the head-quarters of the Council of Education. The Fine Arts section, the larger half at least, is avowedly here only as a temporary expedient; and the other half looks strangely out of keeping with its 'scientific' surroundings of Kindergarten plaiting-sticks, wax models of mutton-chops, and collections of Chinese edibles. In the new building these sections will no doubt be kept more apart. But each is sufficiently important to have a home of its own, or to share in a house devoted to the family of which it is a member. The Museum of Ornamental Art is dfferently circumstanced. That is the specialty of the South Kensington Museum; and, as far as it goes, has been admirably selected, and is in every way creditable to the diligence, taste, and knowledge of those charged with its formation."

We pass over the parliamentary section of the Almanack—in itself a highly useful compendium—and also the curious statistical items which are interspersed, to arrive at the annual summary of "Architecture and Public Improvements," which constitutes a leading feature in this work. The essay touches, of course, upon the "battle of styles" which is still waging with undiminished vigour, although, in practice, the Gothic style is daily extending its conquests. But what it is gaining in extent it is losing in concentration, and the practitioners of Gothic architecture are now anything but agreed as to what is to be understood by the term.

"Once English Gothic was pronounced to be the most perfect development of the style, and the introduction of any foreign element was earnestly deprecated—the only question admitting of difference of opinion being, which of the three periods of English Gothic should be exclusively followed. Perpendicular was early thrust aside by the stricter ecclesiologists, and consigned to a limbo scarcely less profound than that assigned to Pagan architects and architecture. But, one after another, the leading Goths have yielded themselves captive to some foreign form, French or Italian being most in favour; German Gothic having found some admirers, but very few followers: though we should hardly be surprised if her turn came next. Be that as it may, scarcely a Gothic building of any consequence has been recently erected which has not been characterised by some distinctly foreign feature."

In alluding to the churches and chapels which have been either completed or commenced during the present year, the first mentioned is St. Paul's, Haggerstone, by Mr. A. W. Blomfield, avowedly an abandonment of the Mediæval type,—

"It 'being his conviction that the received Mediæval type is not the building best adapted to the ritual of the Church of England.' In this church, therefore, the problem he has attempted to solve is how, 'without sacrificing ecclesiastical character,' a thousand persons should find accommodation so that all may see as well as hear the clergyman. The church is of brick. The roof of the nave is ceiled, but the principal timbers are shown. The aisles are covered by a series of gable roofs, one over each of the five bays. Galleries run along the sides and western end of the church. The real novelty perhaps consists in the free recognition of a material which ecclesiastical architects usually shrink from making visible use of. The main arches of the roof are borne on lofty but slender iron pillars, four on each side, which rest on a base of Portland stone. The galleries, which are set back from the main pillars, are also supported on thin iron columns."

Whatever merits or demerits may attach to the main points of this design, they are not due, unless by a strange coincidence, to the architect just named, since most of the identical leading features had already existed in the new church at Woolwich Dockyard, as may be seen by the view published in a professional journal some time ago. Exeter College Chapel, Oxford, is described at some length, and assigned as the masterpiece of its architect, Mr. Scott. The great height externally, in proportion to the length, is commented upon, also the extravagant and inharmonious colouring of the organ, and the prevailing hue of the stained glass. The groining, which is in stone, is peculiarly well managed, and a perfect piece of masonry. Next (after a passing reference to Balliol College Chapel and Halifax Church) comes a reference to Mr. Scott's little cruciform church at Leafield, Oxfordshire, and the very costly church erected by Lady Willoughby de Broke, at Bodelwyddan, North Wales, the architect being Mr. Gibson. A bare enumeration of a list of buildings being uninteresting (and as we have already allotted so much space to this subject, we are unwilling to devote more), we can only say, that among other well-written descriptions of works of this class will be found, those of the new church in Ryland-street North, by Mr. Bourne, of Dudley; Crumpshall, Manchester; Whitwell, Yorkshire; Waltham Abbey; and Redcliffe Church. Reference is also made to the progress in cathedral restorations which is apparent under the superintendence of Messrs. Scott, Ferrey, Slater, Colson, Perkins, Prichard and Seddon, and Holden. The alterations in our civic St. Paul's, too, are duly chronicled. Then succeeds a list of "restored" churches, headed by St. Michael's, Cornhill (which we have already described at length), and including Wivenhoe, Bridport, Richmond (Yorkshire), Stockton (Shropshire), and St. Mary's, Leicester. The places of worship connected with other denominations are also numerous, but do not call for any special comment.

Of "Buildings for Public Purposes," we find reference to the Offices of the Metropolitan Board of Works, in Spring-gardens; the Manchester Assize Courts; the Cancer Hospital, Brompton; Netley Hospital, "the most mismanaged affair in the country," as Sir J. Paxton pronounced it; and several town halls and corporate buildings.

Among the buildings connected with "Art, Science, and Education," due prominence is given to St. Giles's Parochial Schools, by Mr. E. M. Barry. "Of all our recent London brick buildings none other forms so imposing a mass, or is so striking and effective in expression;" an opinion which we have previously expressed when describing this building.

On Heat, in its relations to Water and Steam: embracing new views of Vaporisation, Condensation, and Explosions. By CHAS. WYE WILLIAMS, A.I.C.E.—London: Longmans. 1860.

It is an agreeable duty to introduce to our readers this valuable book of Mr. Williams, just issued from the press. Its publication has been looked forward to with interest by many engaged both in scientific and industrial pursuits. It is distinguished from previous works on the same subject by entirely new features, which render it useful to the man of science, and bring it also within the comprehension of the less proficient. We allude to the great clearness of its language, the absence of all higher mathematical calculus, and to the systematic order in which the various phenomena of the subject under discussion are brought before the reader. The author commences by explaining the three different states of water, and treats then, in succession, of vaporisation, the diffusion of vapour, the heating and expanding of water, the boiling point, ebullition, vapour in water, condensation, the vacuum, evaporation, spontaneous evaporation, and explosions;—and we may justly say that Mr. Williams has given to the public a work not only of general interest, but of real practical worth to every man whose attention is directed, either by the demands of his profession or by taste for philosophical inquiry, to these phenomena.

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The subject of heat, and the changes effected by it on the element, water, has engaged the study of philosophers of all ages and countries, and much has been advanced in elucidation of its phenomena. The names of Arago, Mariotte, Gay-Lussac, Regnault, Bernouilli, Pambour, and, among our own countrymen, Dalton, Dixon, Lardner, Ure, Thomson, Rankine, Faraday, and many others, are familiar; and such is the amount of information and expounded theories already possessed, that on first consideration it may appear that nothing more could be said on the subject. That this, however, is by no means the case—that, on a closer examination of the theories advanced, many supposed laws are found to be based on mere hypothesis, and that many conclusions arrived at by different experimentalists of unquestioned authority are at variance with each other, will be understood from Mr. Wye Williams's book. It was from these considerations that the author was induced to commence an entirely new course of investigation, and to remodel the whole subject from the beginning. Mr. Williams observes, in pursuing the inquiry, "Much has not only to be learned, but more also to be *unlearned*, before we arrive at a true knowledge of the relations which heat bears to liquids and aeriform matter." He says:

"A consideration of the laws of heat, in reference to this department of science, is not only a branch of the highest philosophy, but is intimately connected with the ordinary concerns of commercial life and social progress. Among the objects in immediate connection with this subject may be classed all that has reference to steam, and its uses, in the steam engine, whether for manufacturing purposes or in steam navigation. It involves all that belongs not only to the generation, but the application of steam, thus embracing a wide field of inquiry. In this point of view, then, the present treatise may be regarded as but an opening of the subject,—an outline or programme of that inquiry which will hereafter be found to embrace meteorology and electricity, with an ultimate attainment of perfection in the steam-engine, and its wonderful adaptation to the wants and business of mankind."

Although, as above stated, the knowledge contributed by different writers on the phenomena of heat is considerable, Mr. Wye Williams's book is not the less welcome, as it embodies the results of researches and patient investigations extending over a period of above half a century. Mr. Williams, in asking for a share of public attention, says that it may be thought necessary that

"An author should account for his coming before the public, on a subject which had long and largely occupied the time and labours of the highest intellect; with the grounds of his pretensions when differing from those who had gone before him. To this reasonable necessity I submit, and, after the manner of Watt, have but to tell 'a plain story.' Not being a professional chemist or engineer, to differ from so many who have higher claims as public instructors, may doubtless appear presumptuous. In these days, however, no writer, whatever may be his standing, can expect that his mere *ipse dixit* should dispense with further inquiry. There are now no secrets in chemistry or philosophy. The highways of science are open to all. The laws of nature are equally accessible by all. On this we are all on a par; and the present work, like those of others, must stand or fall on its own merits. This is, in truth, as much as could be desired by any writer, no man's mere dictum being recognised as sufficient to negative the results of experimental philosophy, when examined under the inferences of right reason. Every man, according to the knowledge that is in him, stands before the great tribunal of common sense, and under the judgment of cotemporaneous information."

It may not be out of place here to give an outline of Mr. Williams's career, of which he presents a sketch in the introductory part of his work. So far back as the commencement of the present century the author's professional pursuits led him to devote his attention more intimately to the study of chemistry, which he commenced at the Dublin Society, then presided over in this branch of science by Prof. Higgins. He also attended the courses of the late Dr. Andrew Ure, with whom he contracted a friendship that terminated only with the life of that celebrated chemist. Mr. Williams subsequently directed his inquiries to the use of coal, and submitted the results of his observations to the public, in 1839, in a book entitled 'On the Combustion of Bituminous Coal.' Of the soundness of Mr. Williams's opinion on this subject some estimate may be formed, from the fact that the book was produced under the supervision of Dr. Ure, with whom he was in constant communication during its progress. Amongst the various inventions or applications of the author during the early part of his career, we may mention the first successful introduction of the use of turf as fuel for boilers in manufactories as well as in river steamboats in the North of Ireland; further, the first introduction of metal gearing for mill-work, as a substitute for the wooden teeth then universally in use. The consideration of the causes of the failure of a steamship company in Ireland next suggested to Mr. Williams the necessity of improving on the propellers then commonly in use, and brought him into communication with the late Mr. Oldham, the result of which was the introduction of an improved propeller, well known under the name of the "Oldham feathering wheel." These improvements led to the formation of a steamship company, which subsequently became developed, and is now known as the City of Dublin Steam Packet Company, of which Mr. Williams was not only the originator, but has been from its commencement the managing director. During this lengthened period he deemed it his duty to those whose interests he represented to make himself thoroughly acquainted with the nature and properties of fuel, and with its economical as well as efficient production of heat, and the application of that heat for the generation of steam. The results of the former he has embodied in the book above mentioned published in 1839, and the experience derived from his inquiries into the latter Mr. Williams has given to the public in the volume before us. Impressed with the value of experimental investigations over theoretical inquiries, and bearing in mind the conviction of Dalton, that "no conception can be firmly grasped by the intellect if it cannot be visibly embodied to the outward senses," Mr. Williams has discarded in his work all proofs by mathematical reduction and formulæ, but has preferred, as he says, "to reduce each view to a visible representation." To this principle he has strictly adhered throughout the book, and examined separately the laws which regulate the conditions of heat, and the phenomena caused by it in union with water and other liquids; and has thus been enabled to trace the simplest causes of nature to the development of the most complex results.

We have here given a brief sketch of the object and views of the author, without remarking especially on the phenomena treated of under separate heads in his book: this we shall defer until our next number.

A Syllabus of Plane Algebraical Geometry. By C. L. Dodgson, M.A., Student and Mathematical Lecturer of Christ Church, Oxford.—Oxford: Parker.

The object of this syllabus is to present a sketch of a concise, logical, and complete system of algebraical geometry. Looked at from this point of view this little book is, in our opinion, marked by merits of no ordinary kind. It begins by stating with great precision those definitions, postulates, axioms, and elementary propositions which are required for the application of algebra to geometry. Now everyone who has carefully thought on this subject must have observed how deficient ordinary text-books are in the statement of definitions, and in demonstrations which are applicable to all instances to which they profess to extend. For example, a book which has been so much praised as Salmon's 'Conic Sections' attempts no satisfactory explation of the positive and negative signs of the radius vector, nor of those of a and p in the well-known equation, $x \cos a + y \sin a - p = 0$. Indeed, in order to do this effectually it would be necessary carefully to extend and modify the ordinary definitions; and although this has been attempted by various authors, including even so eminent a mathematician as Professor De Morgan (see his 'Differential Calculus'), yet we have seen no book in which this object has been so completely attained as in the book we are now reviewing.

The syllabus does not aim at novelty in its results; but this kind of novelty is often of far less importance than novelty of method. We have heard that one of our most eminent mathematicians said, that the most difficult mathematical book to write would be a logical and philosophical work on arithmetic; and in a similar way, the completeness of the system developed in Mr. Dodgson's book, and his strictly scientific method, places it in our opinion far higher than those numerous text-books like Salmon's 'Conic Sections,' whose principal merit consists in importing into our Universities some of the more recent discoveries of continental mathematicians. As this book however contains very few demonstrations, and the reader is referred for them elsewhere, we are afraid that it will only be generally read by those who attend the author's lectures at Christ Church; and we therefore hope Mr. Dodgson will be induced to write a complete work on Analytical Geometry, founded upon the able sketch which has just been published. We think that that sketch bears the same relation to the present state of analytical geometry as an admirable syllabus written many years ago by the late Dean of Ely bore to the then state of trigonometrical science.

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NOTES OF THE MONTH.

New Bridge between Westminster and Lambeth.—Notice has been given by advertisement of an intention to apply to parliament in the ensuing session for power to form a bridge, to be called Lambeth bridge, between Market-street, Westminster, and Church-street, Lambeth, and to take tolls, make approaches, &c.

Australian Coal.—A recent report of the comparative value of Australian and English coal for steam purposes, drawn up by Mr. Anderson, the Inspector of Machinery at Woolwich, furnishes the following results:—The coal first experimented on was the remnant of 300 tons, supplied in the colony to the Oneida, and presented to the Australian Agricultural Company after the arrival of that ship at Southampton. While the Whitworth coal, which is a generic term for Wall's-end, Pelan Primrose, Lambton, &c., produced in a given time 4000 revolutions of the engine, the Welsh coal 4367, and the Hartley 4290, the Australian coal produced only 3950. The directors of the company appear not to have been content the with coals experimented upon, for in April 1859, selected samples sent to England in canvas bags from the Australian Agricultural Company's pits, became the subject of new experiments, the result of which showed a decided improvement, the engine on the second experiment being driven at the rate of 4080 revolutions, showing a superiority of 80 revolutions over the Whitworth coal, but an inferiority of 287 revolutions as regards Welsh coal. Subsequently, Mr. Abel, chemist to the War Department at Woolwich, chemically examined the coal to test its gas-producing powers, and reported as follows: "The quantity of volatile matter furnished by the coal amounted to 71 per cent., and 29 per cent. of a very light and porous coke were obtained. The coal is therefore of a highly bituminous character, and would probably be found exellently adapted for the manufacture of gas." As an example of its gas-producing powers it is stated that the Australian gas, consuming only 5 feet per hour, gives a light equal to $6\frac{2}{10}$ feet per hour of the gas obtained from the Whitworth coal. Mr. Abel concludes his reports with these words, "It would appear from the chemical examination of this coal that it is adapted for ordinary purposes, and for the manufacture of gas, but it will not be found equal in value to the description of coal especially employed for steam purposes."

Extension of the Telegraph System.—The United Kingdom Electric Telegraph Company, which, by carrying out the inventions and plans of Mr. Thomas Allan, is about to give the public cheap telegraphy in the shape of shilling messages all over the country, has commenced operations. The canals are to be adopted as the routes for the new wires.

Automatic Car Couplings.—The many dangers attending the ordinary method of coupling cars, by stepping in between them and placing the bolt in position by the hand, renders any improvement which will do away with the necessity of going between the cars very desirable. There have been many contrivances by which inventors have sought to accomplish this object; and many patents have been granted, nearly all of which have been complicated in construction, unsafe in operation, and always getting out of order. The invention we have in mind was patented by Messrs. Lapham and Burns, May 25th, 1858, and from the simplicity of its construction, and the perfect working of the model which we have inspected, we do not see why it will not prove perfectly successful when reduced to practical working upon our cars. The whole machinery consists of but three pieces—the common link, a tilting hook, and a crooked weighted lever resting upon a fulcrum. As the link is pushed into the bumper it strikes the tilting hook, forcing it back and throwing up an arm between the sides of the link, and secures the link firmly against the interior front of the bumper. At this point the crooked weighted lever falls by its own weight, and securely fastens the tilting hook in its position, and the two cars are thus firmly fastened together. When it is desired to uncouple the cars, a chain or rod fastened to the crooked weighted lever is raised, and this relieving the tilting hook, the link is allowed to pull out. This seems to be so simple that it cannot but be successful, and the many lives annually lost will justify the expenses necessary to place it upon all our cars.—*American Railroad Journal.*

Stone-breaking Machine.—A machine is now being completed at the great ironworks of Creusot, France, which will dispense with the painful necessity of employing human labour in the breaking of stones upon the roads. By this machine, invented by M. Dumarchais, of Saint Gengoux, blocks of granite of enormous weight are reduced in a moment to stones the size of which may be determined beforehand.

Restoration of Llandaff Cathedral.—The restoration of the fine old cathedral of Llandaff is rapidly approaching completion, and is being carried out in the most perfect manner, by the diocesan architects, Messrs. Prichard and Seddon.

Bridge over the Savannah River, Charlestown and Savannah Railroad.—The bridge across the Savannah is to be a grand structure, unequalled perhaps by any similar work in the Southern States. The span is between 900 and 1000 feet, and instead of the usual wooden or stone piers it will rest on hollow iron cylinders, which penetrate the bed of the river and rest upon a solid clay foundation. These cylinders are in sections, 2 inches thick, 6 feet in diameter, and 9 feet in length, weighing each 12,500 lb. They are united to each other by means of flanges on the inner side, secured by bolts, a circle of india-rubber being placed between so as to render them air-tight. These sections are placed one on top of another until the desired length is obtained, and arranged in pairs across the river, about 100 feet apart. It were impossible to get a firmer or more permanent basis for the superstructure. The manner of sinking these cylinders into the earth affords a beautiful illustration of the triumph of scientific principles when applied to the practical utilitarian affairs of life. Instead of being driven as ordinary piles, they are sunk to the required depth through the solid bed of the river, in some instances to the depth of 35 feet, by atmospheric pressure. Two or more of the sections, as may be necessary according to the depth of water, are bolted together and set upright in the river, both ends being open, and the lower one resting upon the bed. Over the upper, which reaches above the surface of the water, is then placed a cap, of the same diameter, and fitting air-tight upon it, the top of course being closed. The process of sinking is then accomplished by exhausting the air in the submerged cylinder, which being done, the pressure of the atmosphere upon the top of the cap sinks the whole mass to the required depth, the cylinder making its way downwards through all obstacles, and without any other application of force whatever. The exhaustion is effected by means of india-rubber tubes, connected one end with the cap and the other with two large cast-iron receivers, 30 feet in length by 6 feet in diameter, on board a flat, which is moored at the spot, and contains all the machinery, including a steam-engine, cerrick for keeping the cylinders in position, &c. The engine puts in motion an air-pump, which first exhausts the two receivers; the valves of these being then opened, the air in the cylinder to be sunk rushes through the india-rubber tubes to fill up the vacuum, and the iron pier gradually sinks into the earth from the pressure of the atmosphere above, as before stated. Nothing can exceed the simple beauty of this operation, which to the unscientific mind has the appearance of magic or legerdemain. The water and sand are removed from the cylinders by means of pumps, &c.; and when all are sunk they will be cleaned out and filled with concrete—thus forming a solid column from bottom to top. It is estimated that it will require a twelvemonth to complete the bridge and have it ready for the passage of the cars. The bridge is being constructed under the supervision of Capt. W. S. Smith, C.E., and Mr. M. P. Muller, C.E.—*American Railroad Journal.*

COMPETITIONS.

Designs are invited for a Music Hall for the Birkenhead Music Hall Company; cost not to exceed £4000. To comprise a public room to seat 600 persons, with refreshment room, cloak rooms, ante rooms, keeper's house, &c. Plans, 8 ft. to an inch. Premium 20 guineas. Plan of site, &c. on application to Mr. H. G. Coventry, 10, Sweeting-street, Liverpool, to whom designs are to be sent by the 1st of January next.

Designs are required for a building to combine Town-hall, Court-house, Public-offices, Library and Museum, at Northampton. Plan of site, &c., on application to Mr. John Jeffery, town clerk, to whom designs must be sent by the 4th of January next.

Designs are wanted for effecting increased accommodation for the General Infirmary at Leeds, by additions and alterations to the present building, a plan of which can be obtained at the infirmary. Premium, £160; should successful competitor be engaged as superintending architect, premium to be merged in commission. Designs to be sent to the infirmary by the 1st of February next.

END OF VOLUME XXIII.

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Jan^{y} 1860

NORTH EAST VIEW— DELAMORE HOUSE, IVY BRIDGE, DEVONSHIRE.

J. P. St AUBYN, ARCH^{T}

J. R. Jobbins

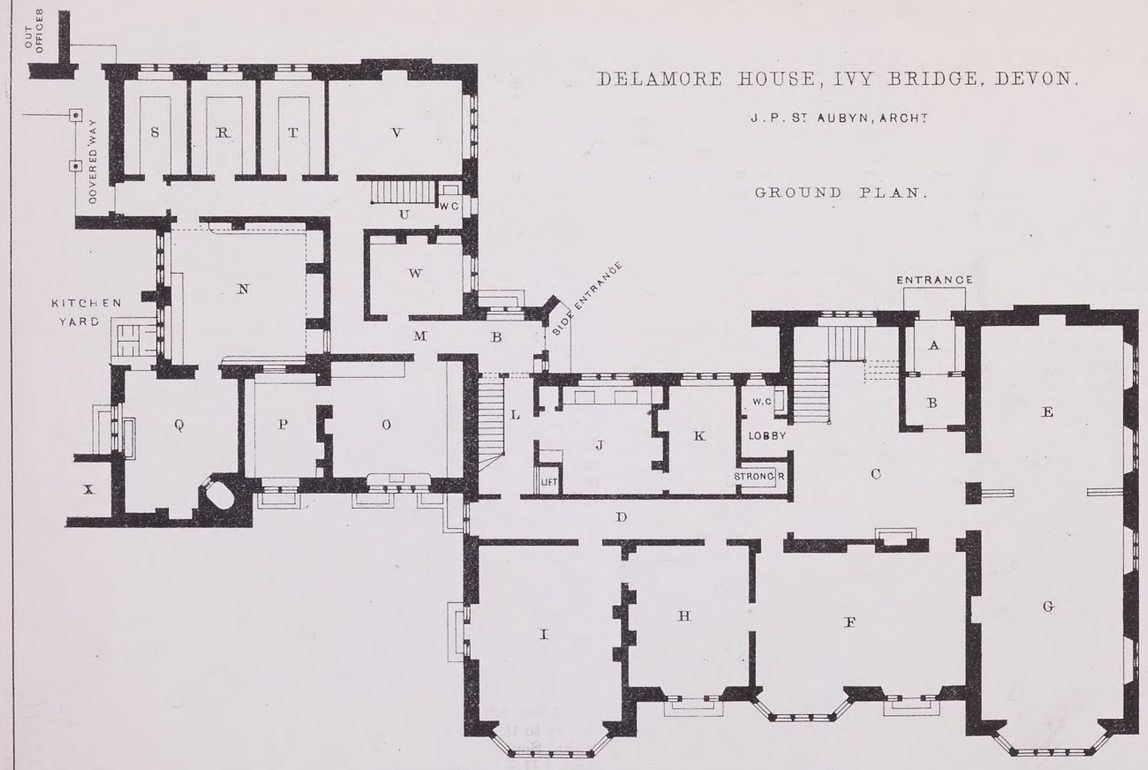
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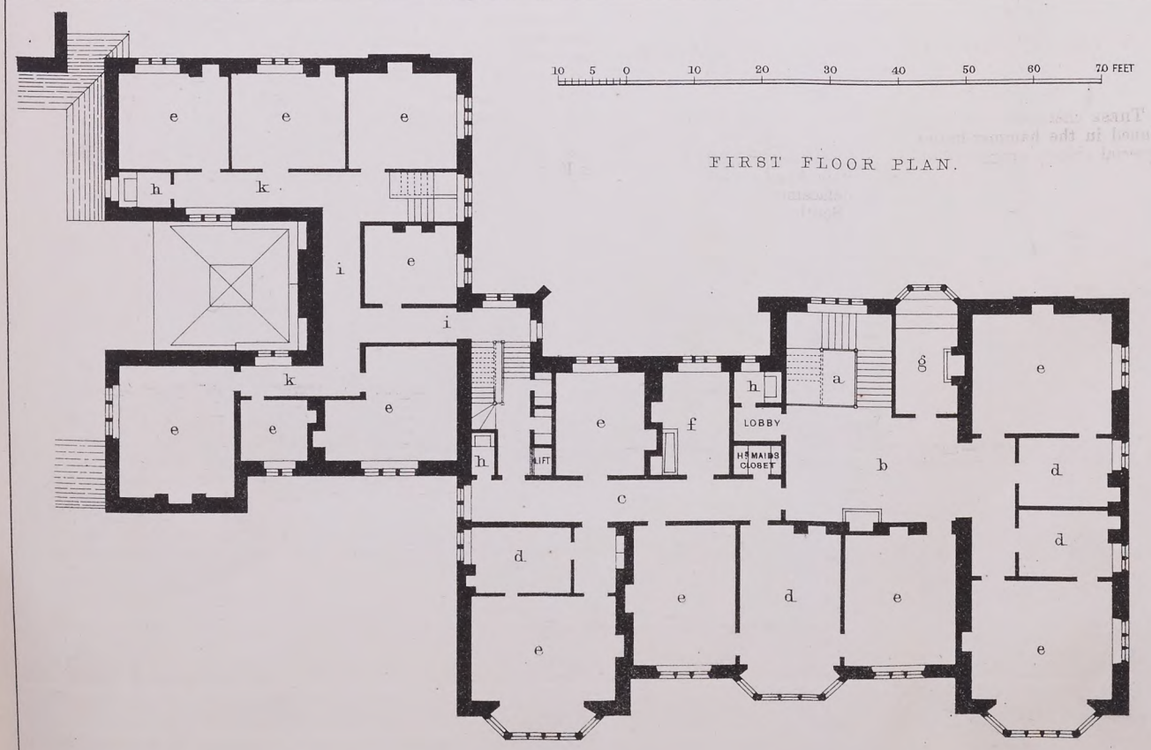
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DELAMORE HOUSE, IVY BRIDGE, DEVON.

J. P. ST AUBYN, ARCHT

GROUND PLAN.





FIRST FLOOR PLAN.

Jan.y 1860

J.R.Jobbins.

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J.D.Wyatt, del. J.R.Jobbins

Feb.y 1860

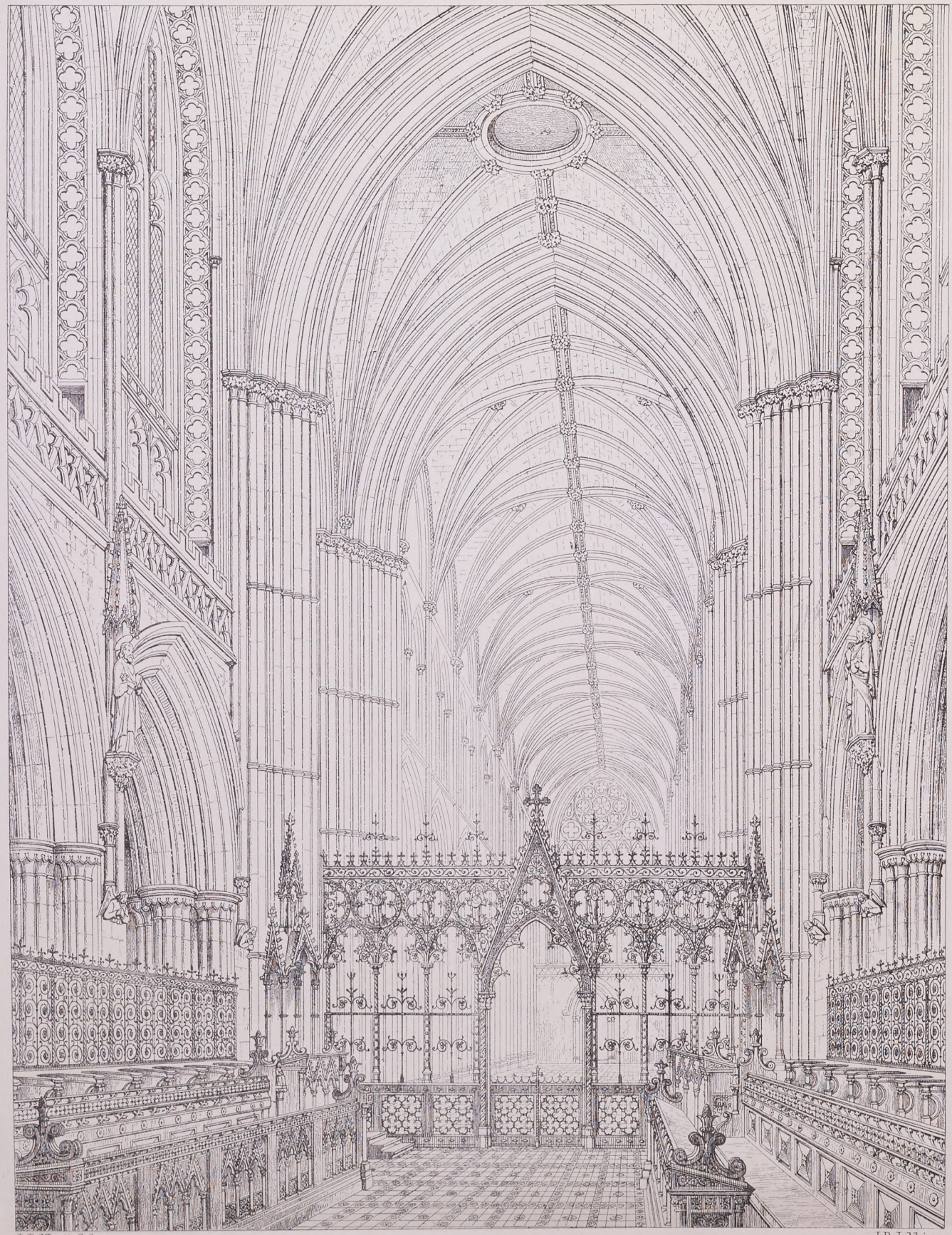
LICHFIELD CATHEDRAL.

VIEW, LOOKING EASTWARD IN CHOIR, SHEWING PROPOSED REREDOS, THRONE AND STALLS.

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

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J.D. Wyatt, del. J.R. Jobbins

Feb? 1860

LICHFIELD CATHEDRAL.

VIEW, LOOKING WESTWARD IN CHOIR, SHEWING PROPOSED SCREEN, STALLS, &c.

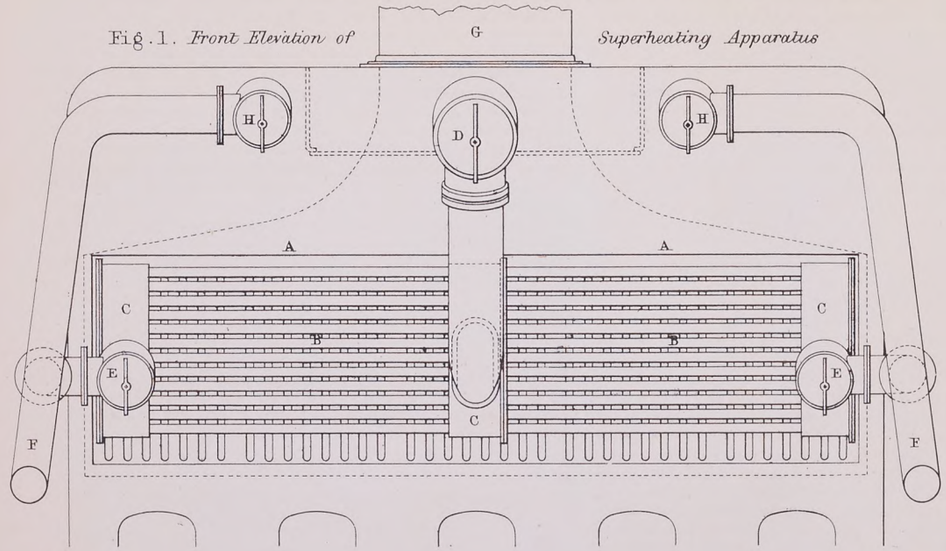
G. G. SCOTT, A.R.A. ARCHT. LONDON.

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PENNS SUPERHEATING STEAM APPARATUS.

Fig. 1. *Front Elevation of Superheating Apparatus*



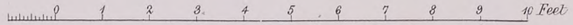


Fig 3.

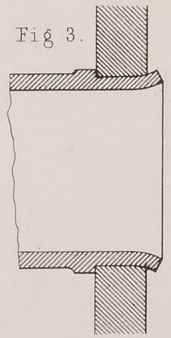
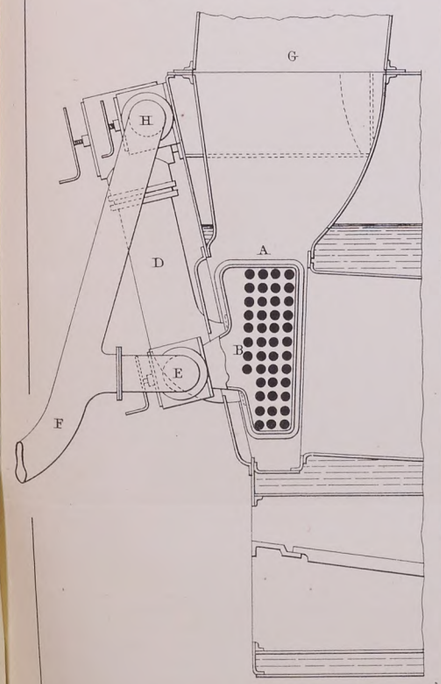
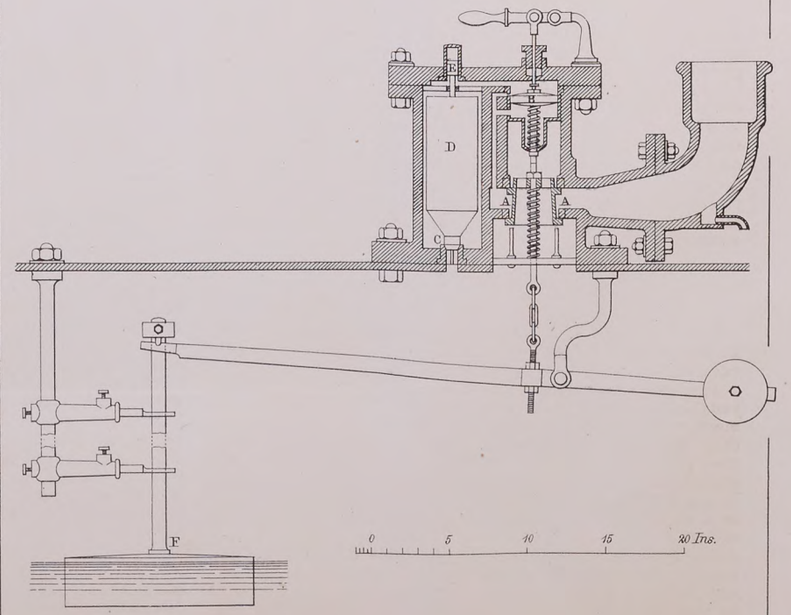


Fig. 2. *Transverse Section*



HASTE'S SAFETY VALVE



Feb.ʸ 1860

J.R.Jobbins

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W. Purdue, delt. March 1860 J.R. Jobbins

ST MATTHEW'S CHURCH, COBO, GUERNSEY.

JOHN JOHNSON, ARCHT LONDON.

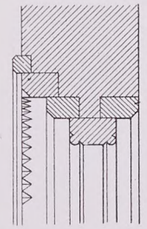
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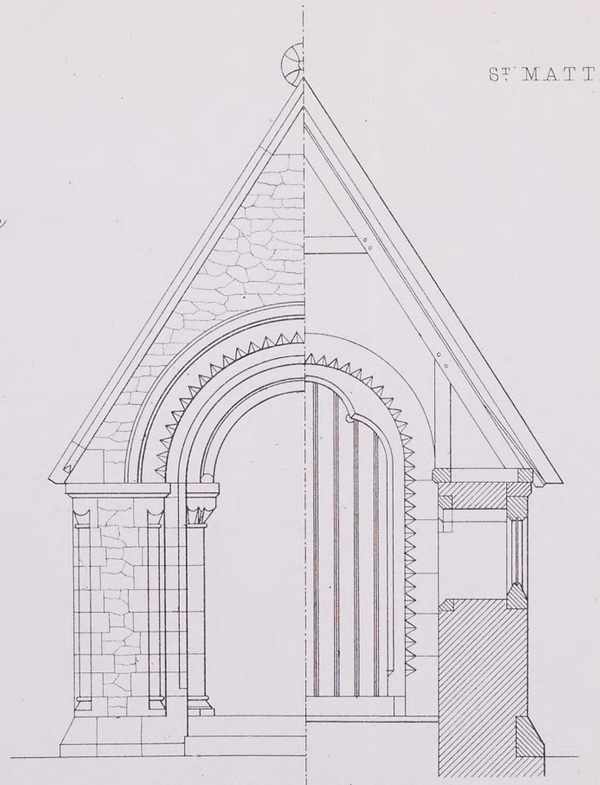
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DETAILS OF
ST. MATTHEW'S CHURCH, COBO, GUERNSEY.

JOHN JOHNSON, ARCHT. LONDON.

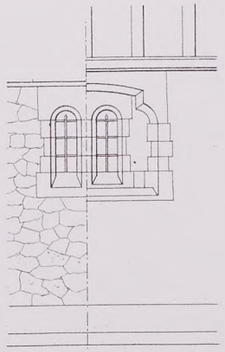
Section thro Arch





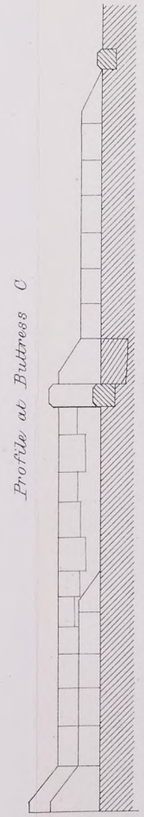
Elevation ½ Inside Door

Porch



Porch Windows

Exterior Interior

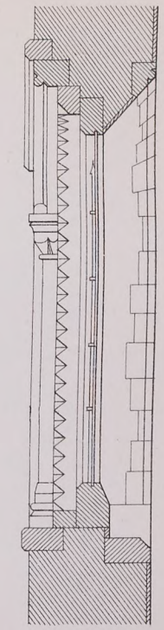


Profile at Buttress C

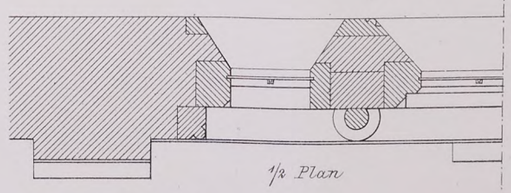


West Window

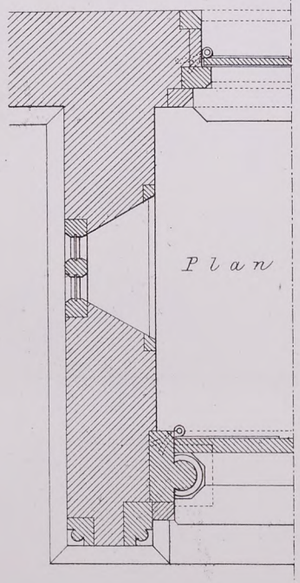
Exterior Interior



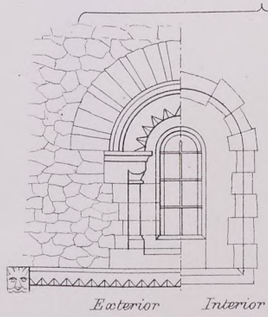
Section at A.B.



½ Plan

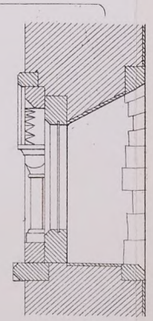


Plan

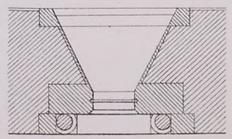


Exterior Interior

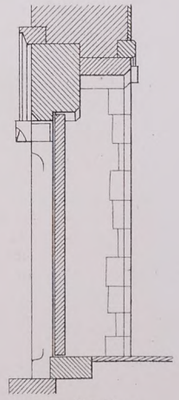
Window in Gable



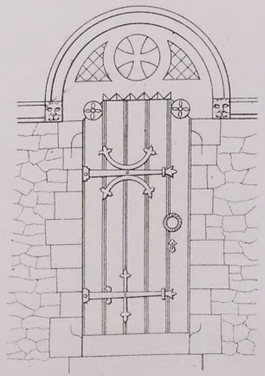
Section



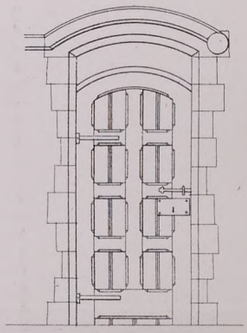
Plan



Section

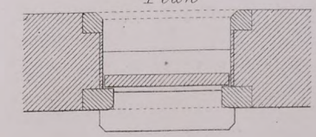


Exterior



Interior

Door to Chancel



Plan

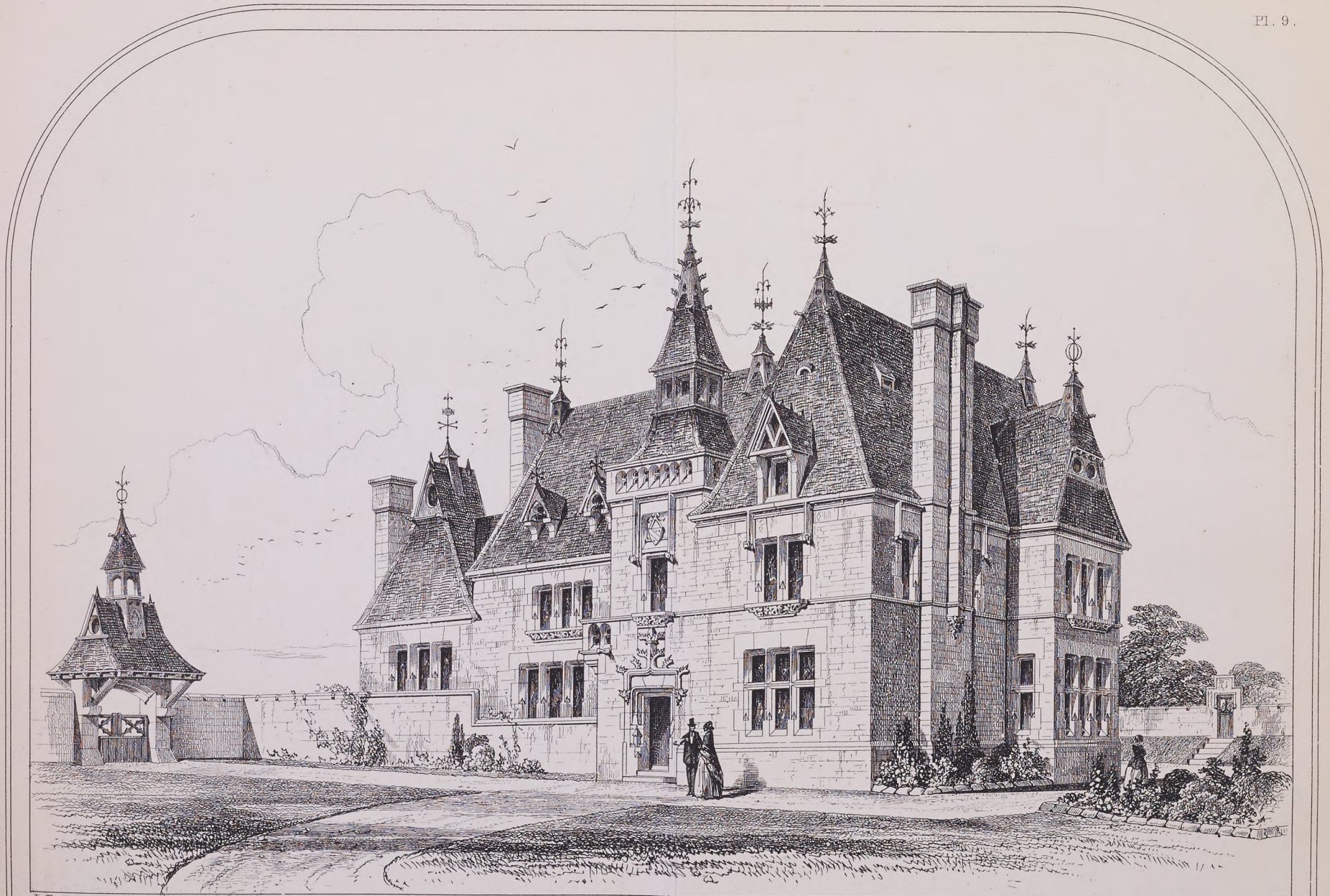
¼ Inch Scale

March 1860

J.R.Jobbins

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J. Bentley, delt. March 1860. J.R.Jobbins

WESTON RECTORY, SUFFOLK.

E. L. BLACKBURNE, ARCHt LONDON.

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CORN EXCHANGE CHAMBERS,
SEETHING LANE, LONDON
E. I'ANSON, ARCHT.

April 1860

J.R.Jobbins

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FRYER'S WATER RAISING APPARATUS.

Fig. 1. *Side Elevation*

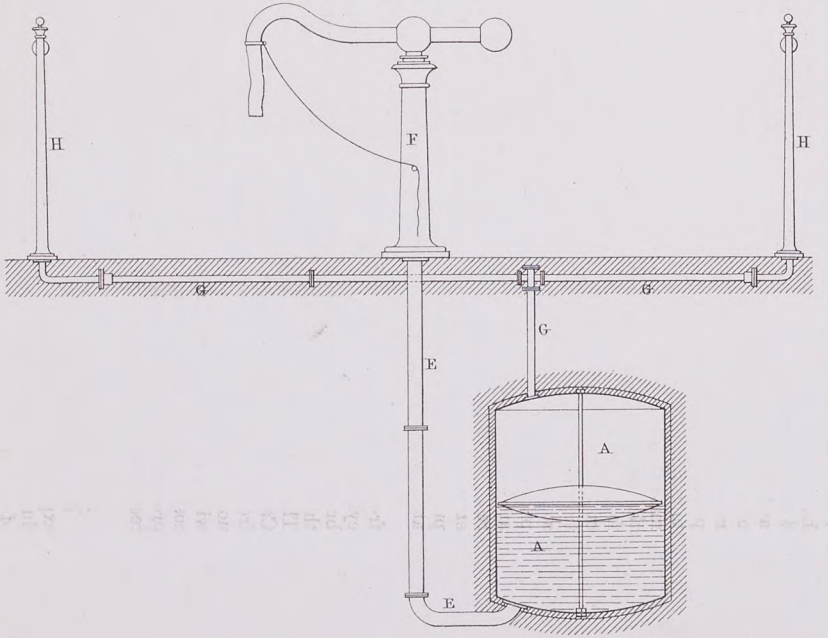


Fig. 2. *Plan.*

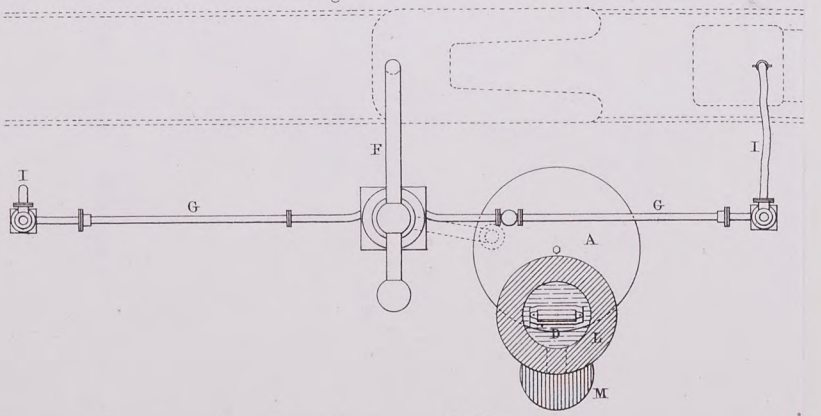


Fig. 3.
Scale 1/300th

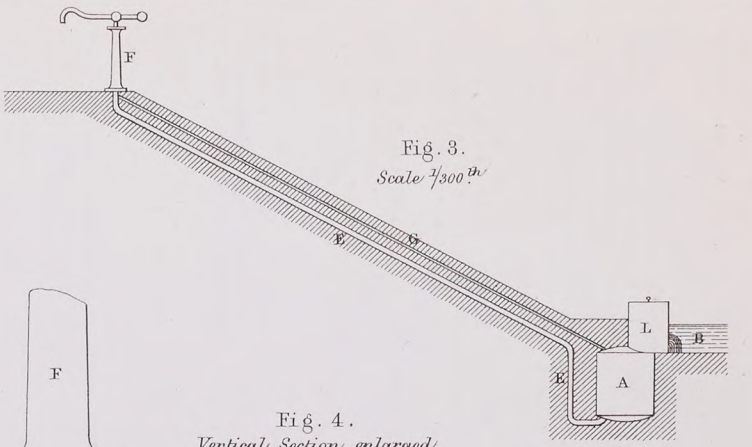
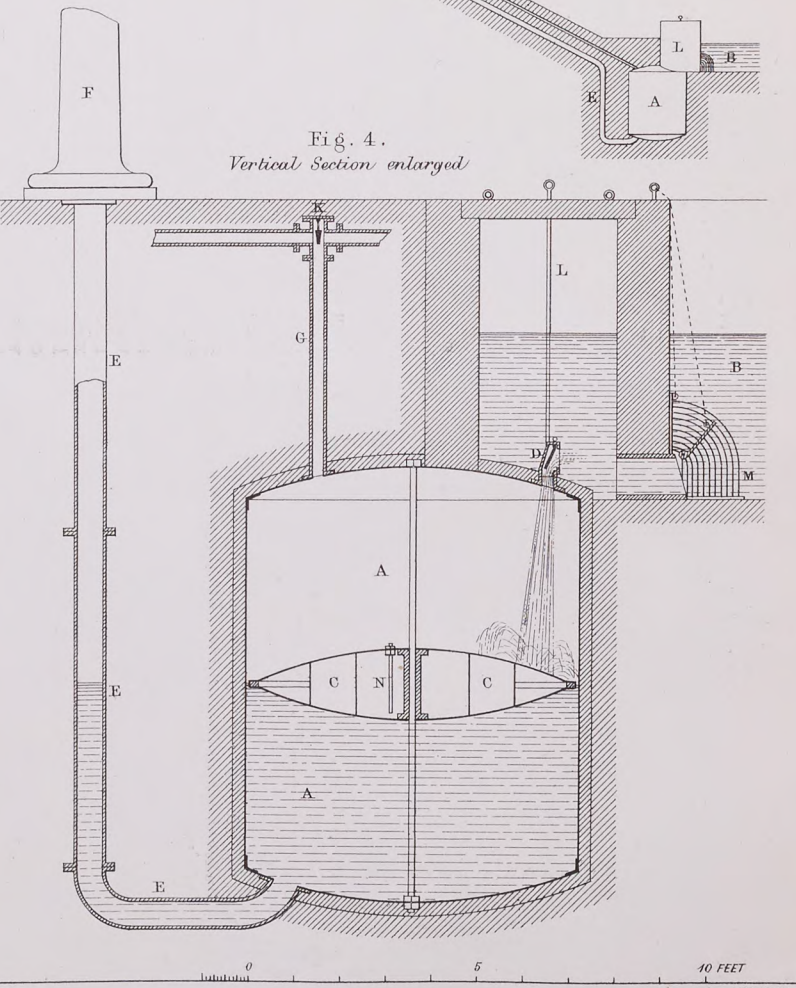


Fig. 4.
Vertical Section enlarged



April 1860

J.R.Jobbins.

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May 1860

J.R.Jobbins.

MANSION FOR GEORGE GLEN ESQ^RE AT STRATTON AUDLEY, OXFORDSHIRE.

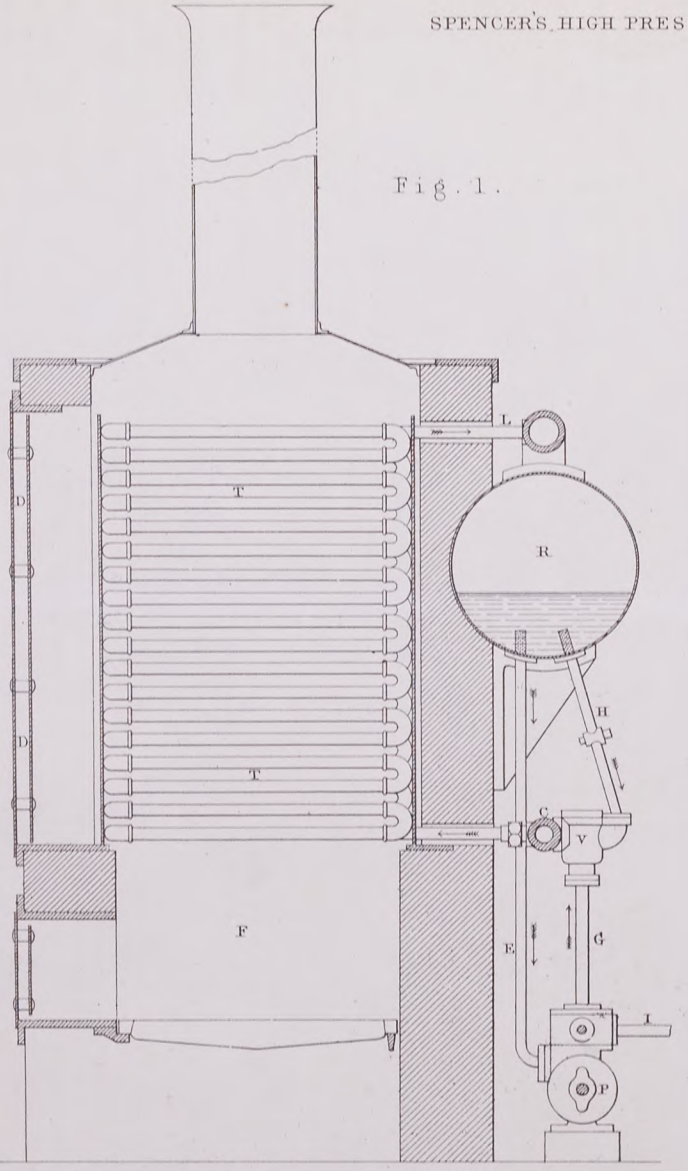
J. ROGER SMITH, ARCHT A.I.B.A.

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SPENCER'S HIGH PRESSURE STEAM BOILER.

Fig. 1.



Scale for Fig. 1 & 2.

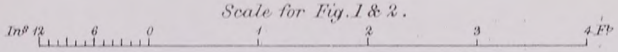


Fig. 2.

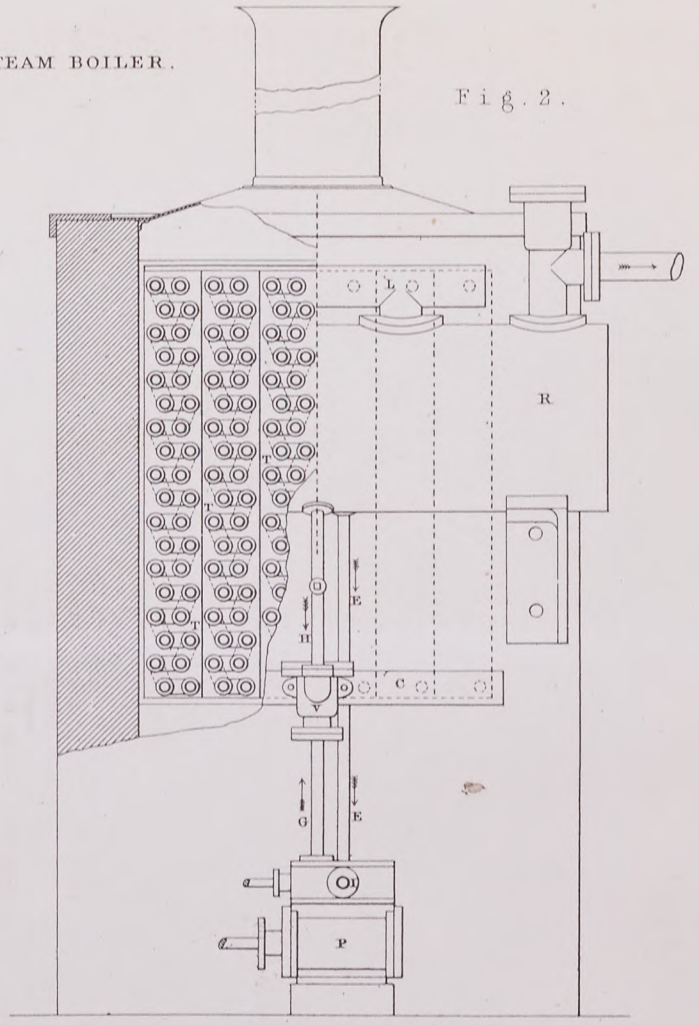


Fig. 3.

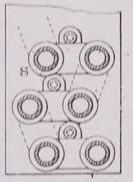
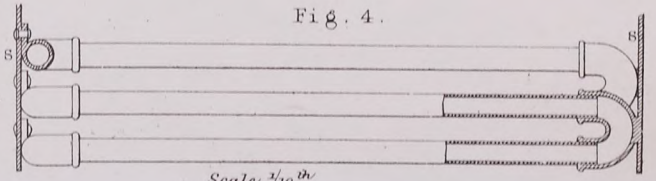


Fig. 4.



Scale 3/10 Ins.

May 1860

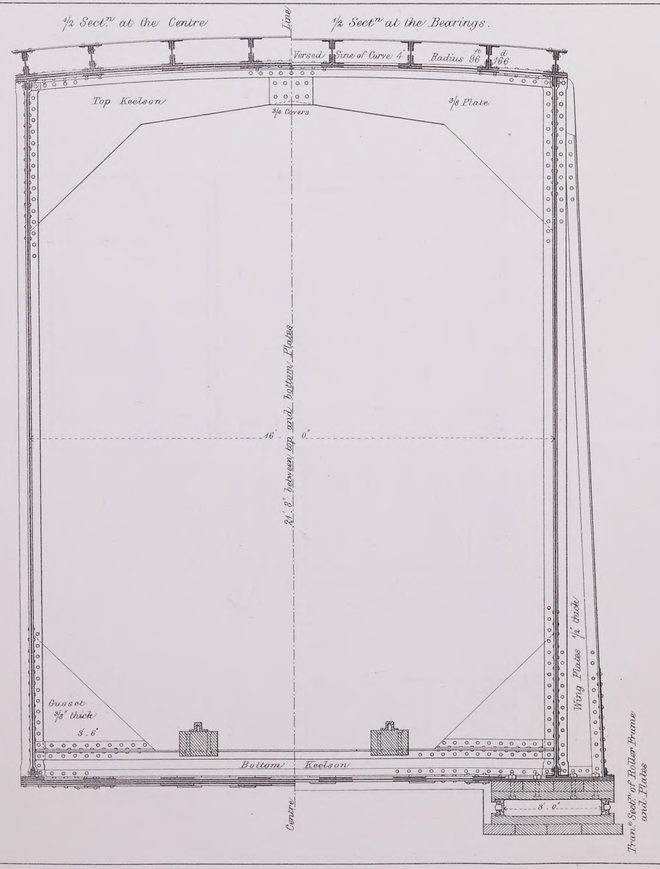
J.R.Jobbins.

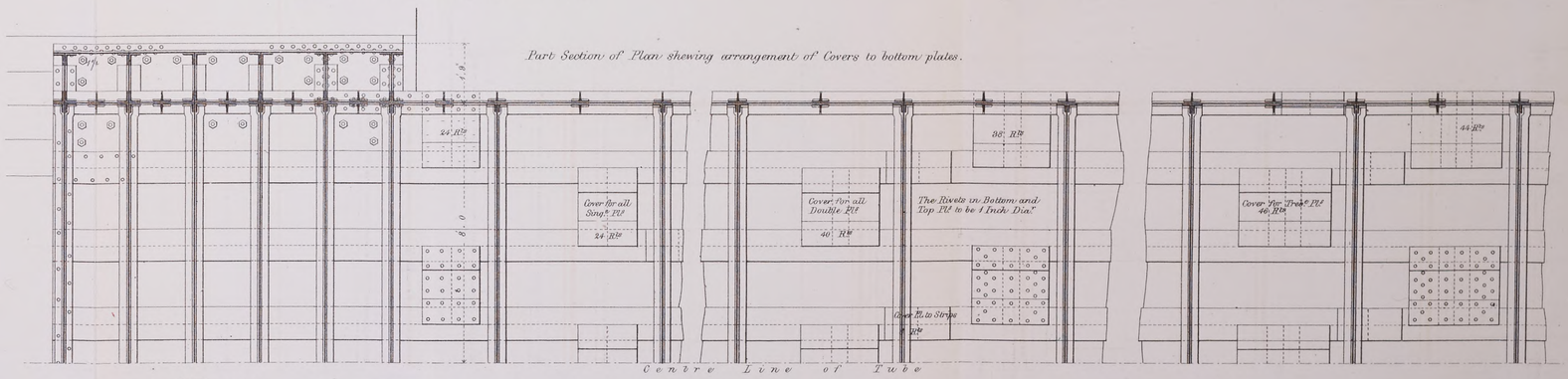
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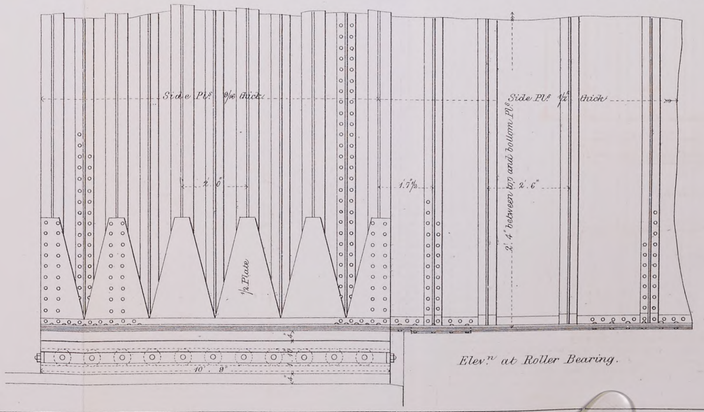
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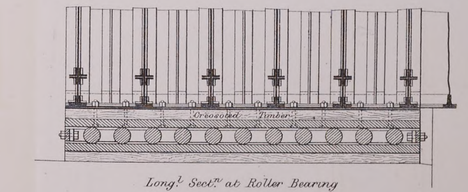
THE VICTORIA BRIDGE, OF THE GRAND TRUNK RAILWAY, CANADA.

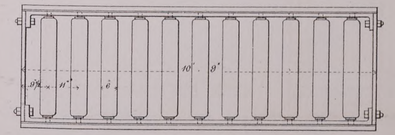
Tubular Beam for the central opening 330 Ft. Span.

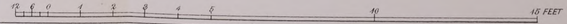












J.R. Robinson

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June 1860

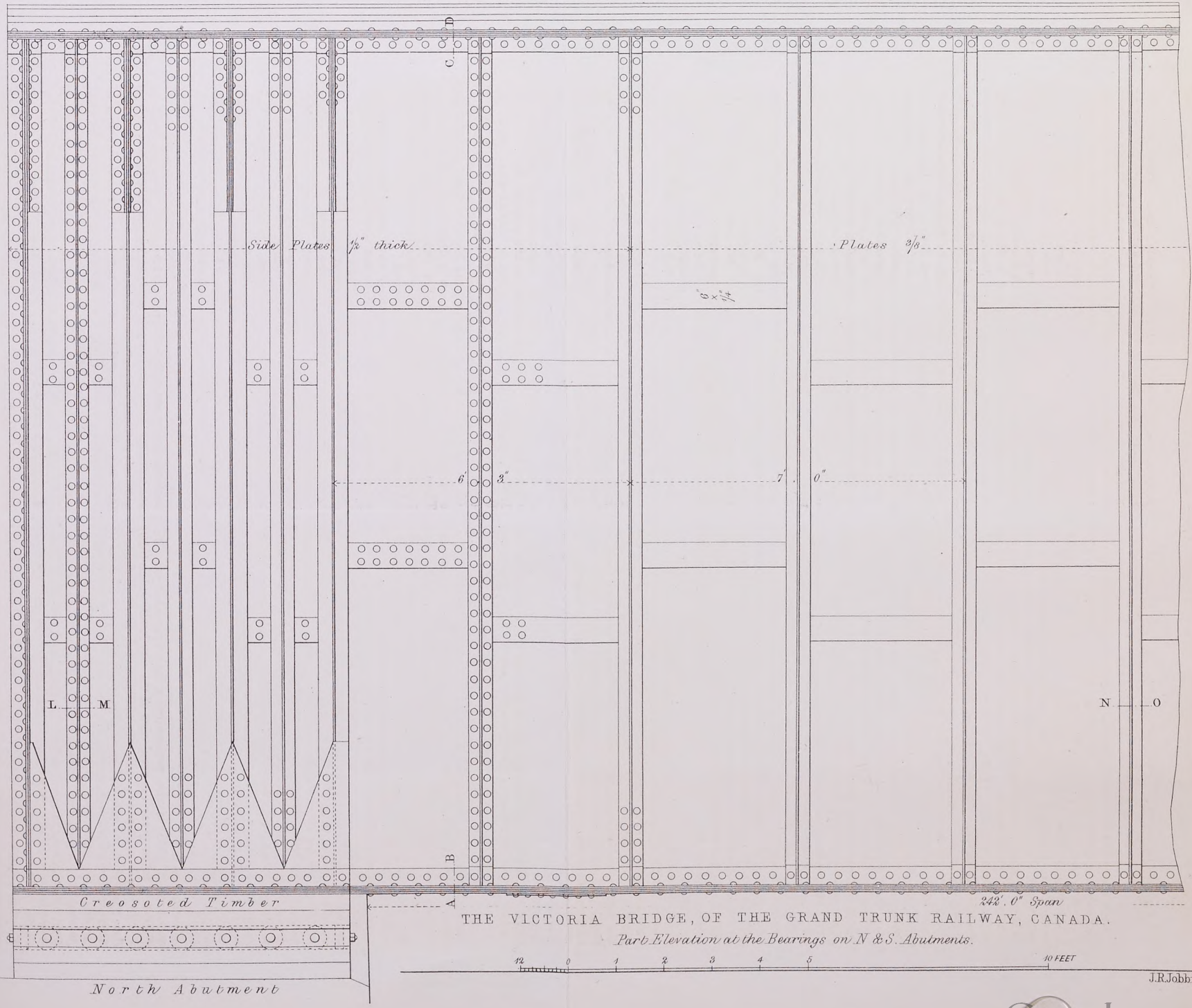
The Church of St. John in the District of Maindee
In the Parish of Christchurch, Newport, Monmouthshire.

MESSRS PRICHARD & SEDDON, ARCHTS

J.R. Jobbins

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THE VICTORIA BRIDGE, OF THE GRAND TRUNK RAILWAY, CANADA.

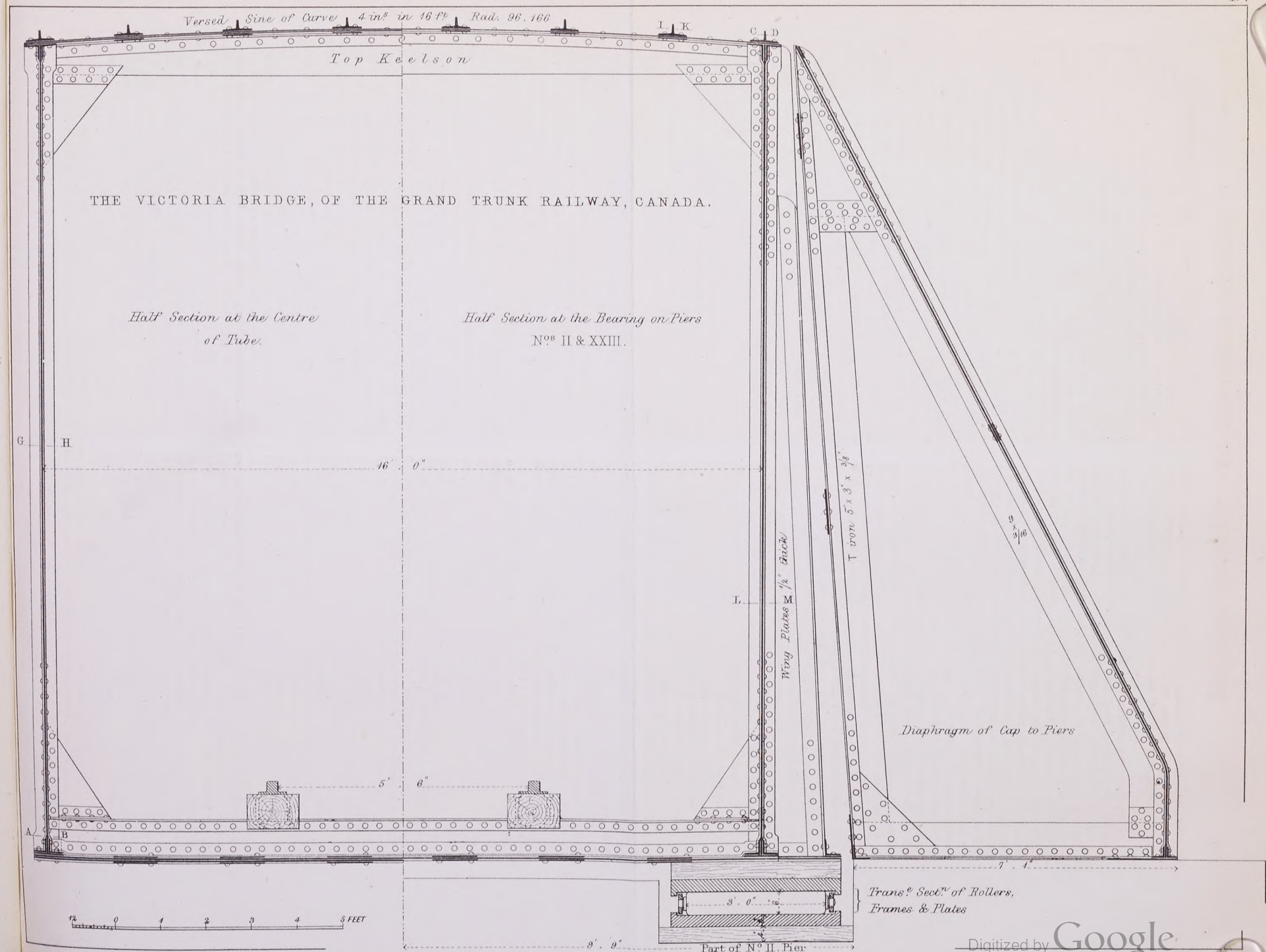
Part Elevation at the Bearings on N & S. Abutments.

12 0 1 2 3 4 5 10 FEET

J.R.Jobbins.

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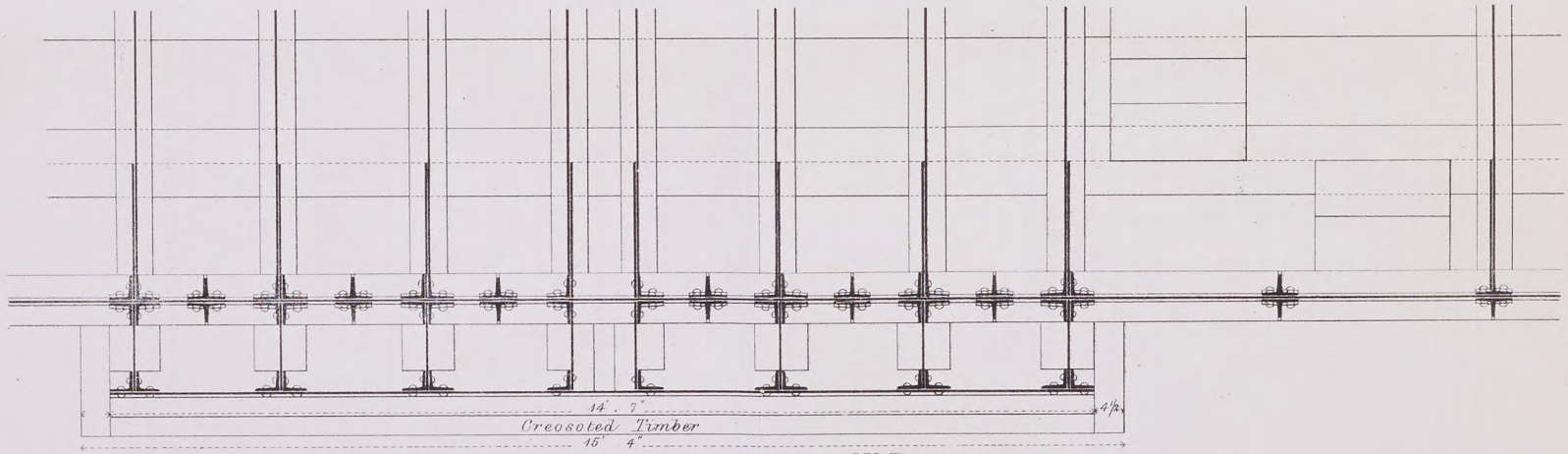
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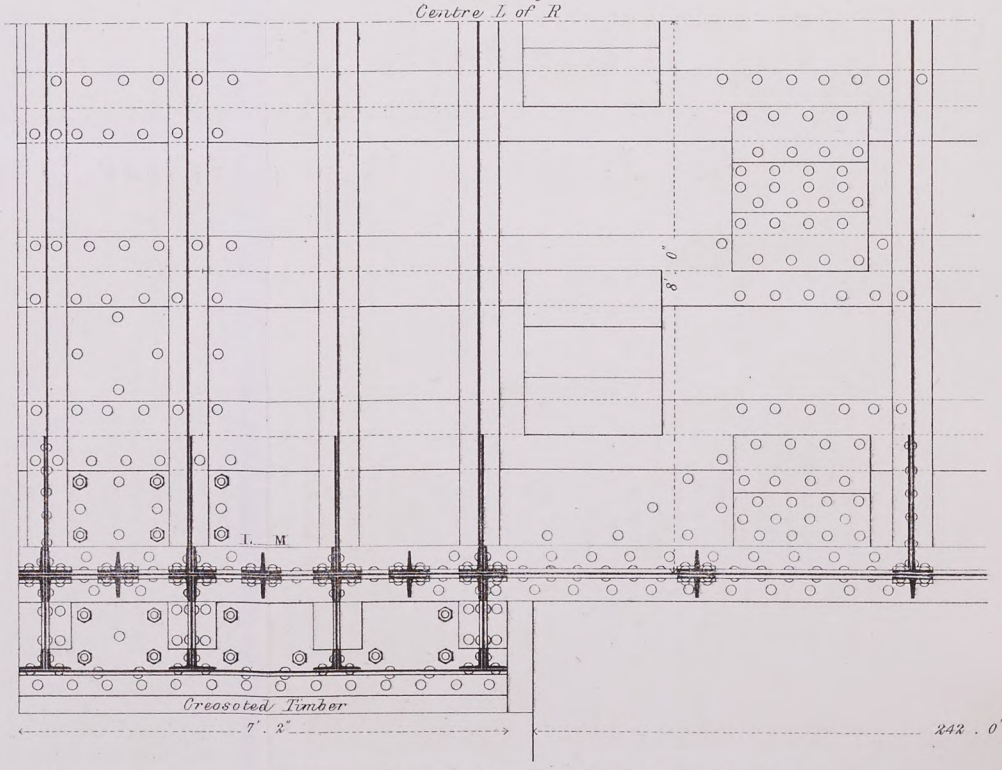
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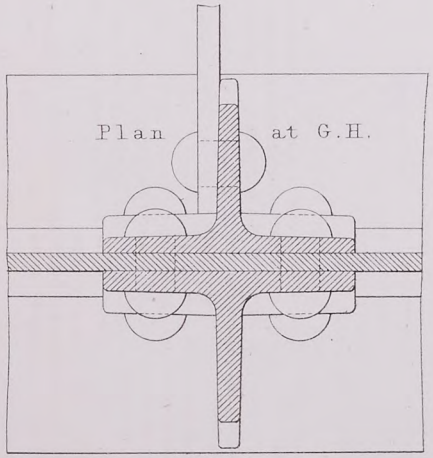
Part Plan at the Bearings without Rollers for Piers Nos I & XXIV.



Pier No I.

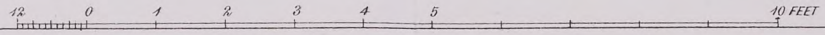
Half Plan at the Bearings with Rollers
Centre L of R





¼ Real size

THE VICTORIA BRIDGE, OF THE GRAND TRUNK RAILWAY, CANADA.



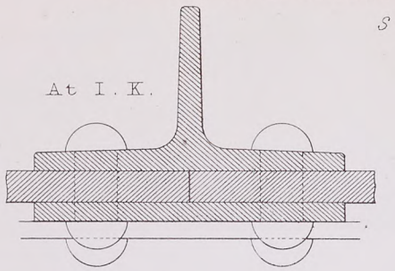
J R Jobbins

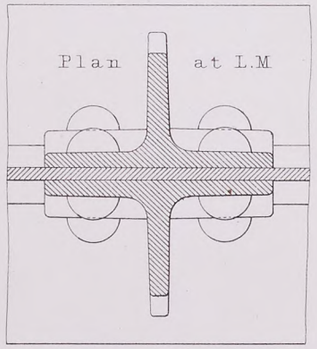
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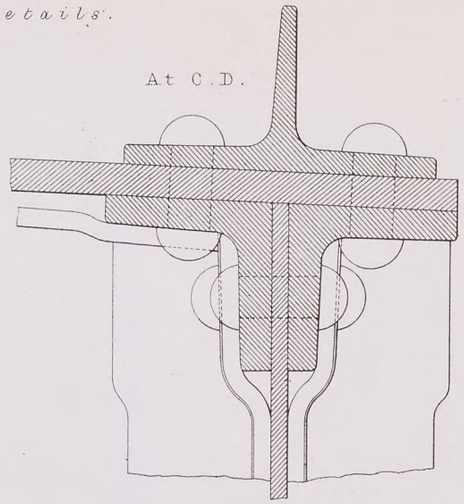
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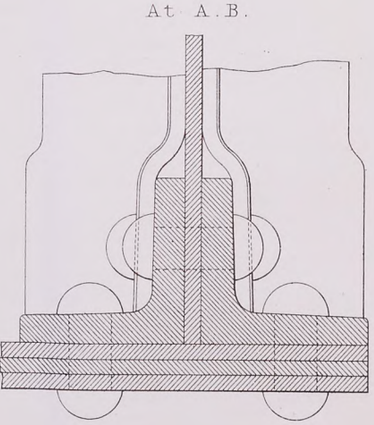
THE VICTORIA BRIDGE, OF THE GRAND TRUNK RAILWAY, CANADA.

Sectional Details.

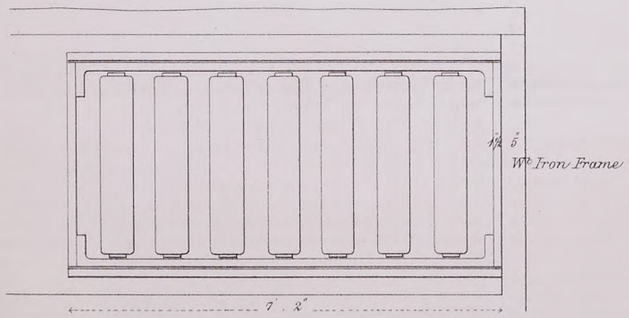


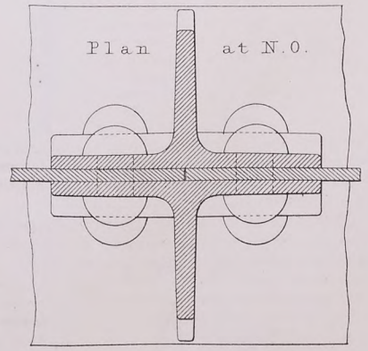




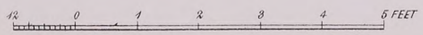


Plan and Section of Rollers and Plates





Details 1/4 Full size



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J.R Jobbins

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Aug.t 1860 J.R.Jobbins

COOMBE CLIFFE HOUSE, CROYDON, SURREY.

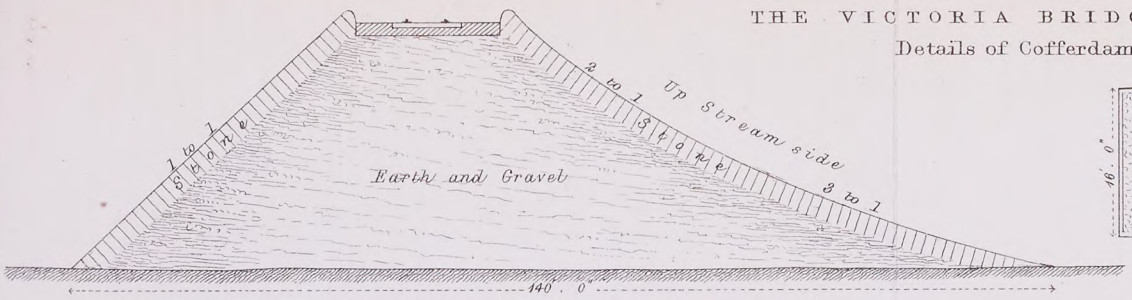
E.C.ROBINS, ARCH.T

Digitized by Google

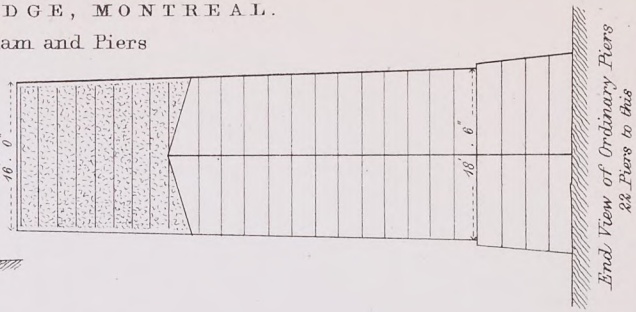
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THE VICTORIA BRIDGE, MONTREAL.

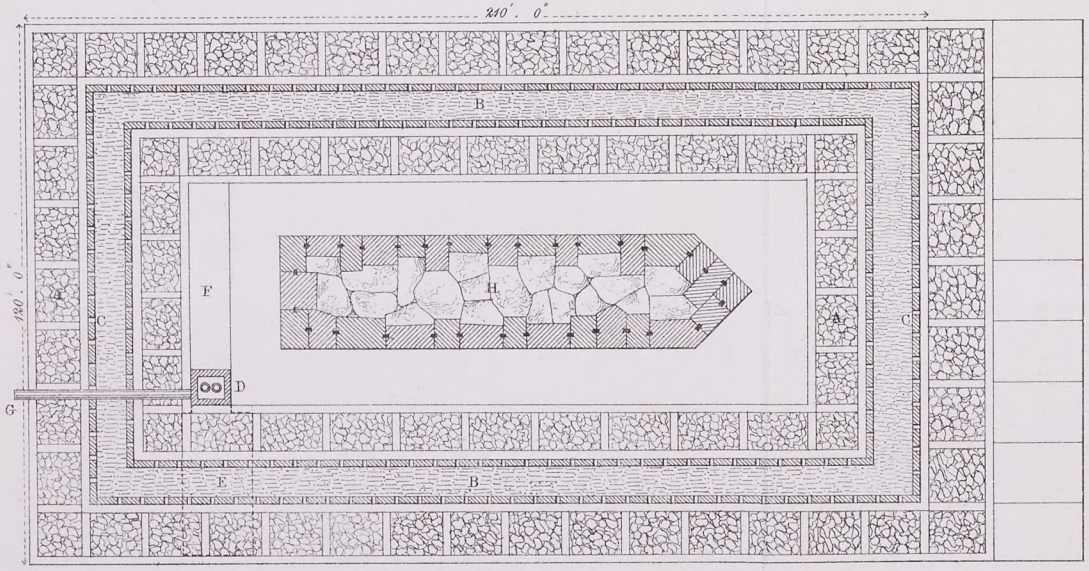
Details of Cofferdam and Piers



Average Section of Embankment in each approach

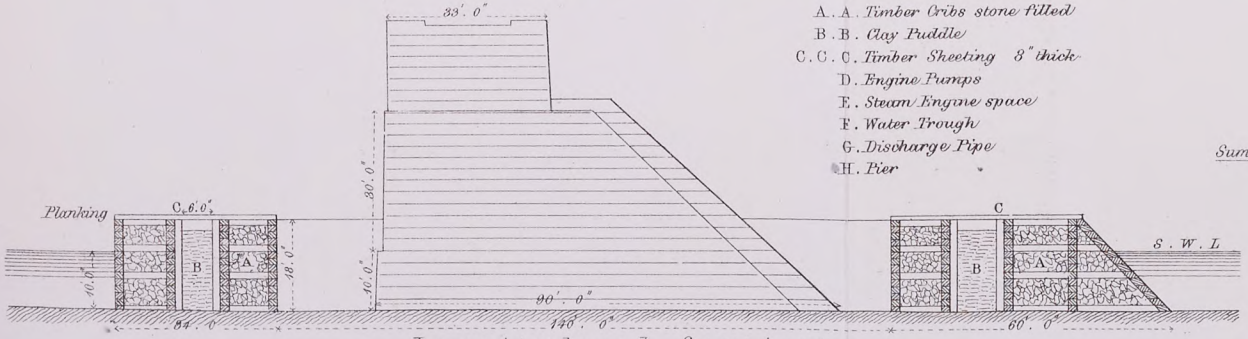


End View of Ordinary Piers
22 Piers to this

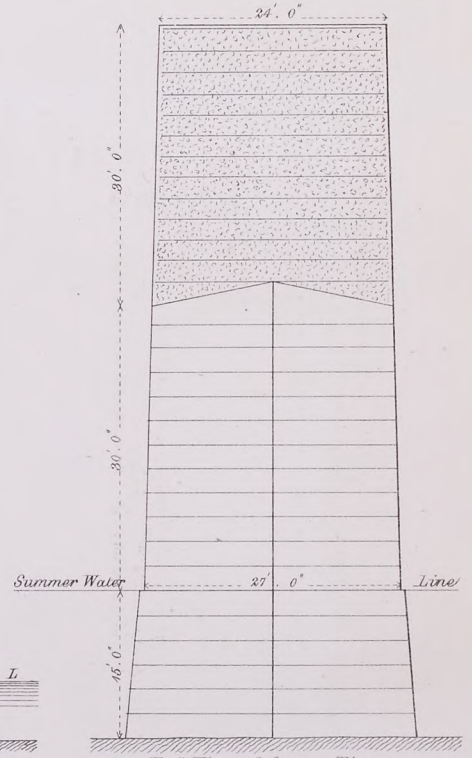


Sectional Plan of Cofferdam & Pier.

A. A. Timber Cribs stone filled
B. B. Clay Puddle
C. C. C. Timber Sheeting 3" thick
D. Engine Pumps
E. Steam Engine space
F. Water Trough
G. Discharge Pipe
H. Pier



Longitudinal Section



End View of Centre Piers.
(2 to this) Nos 12 & 13

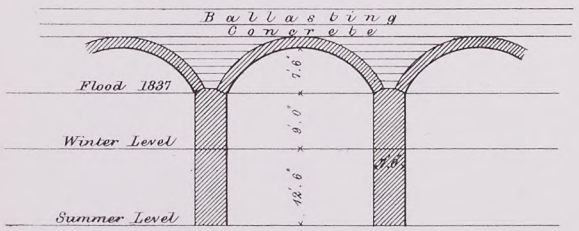
Augt 1860

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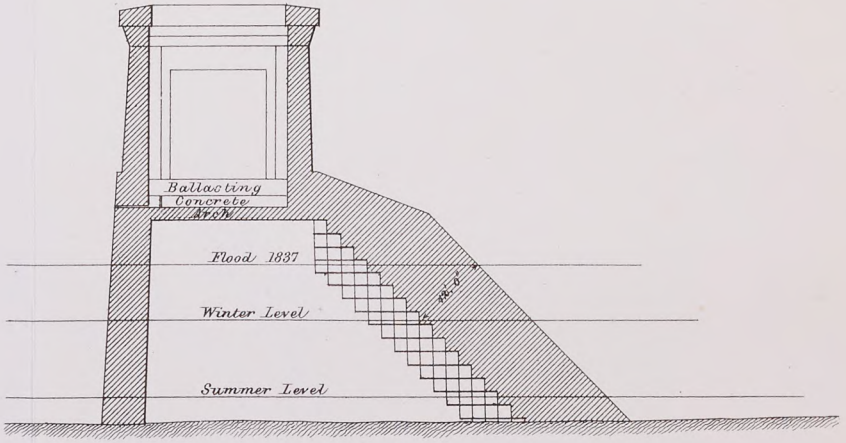
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THE VICTORIA BRIDGE, MONTREAL.

Plan and Sections of South Abutment.

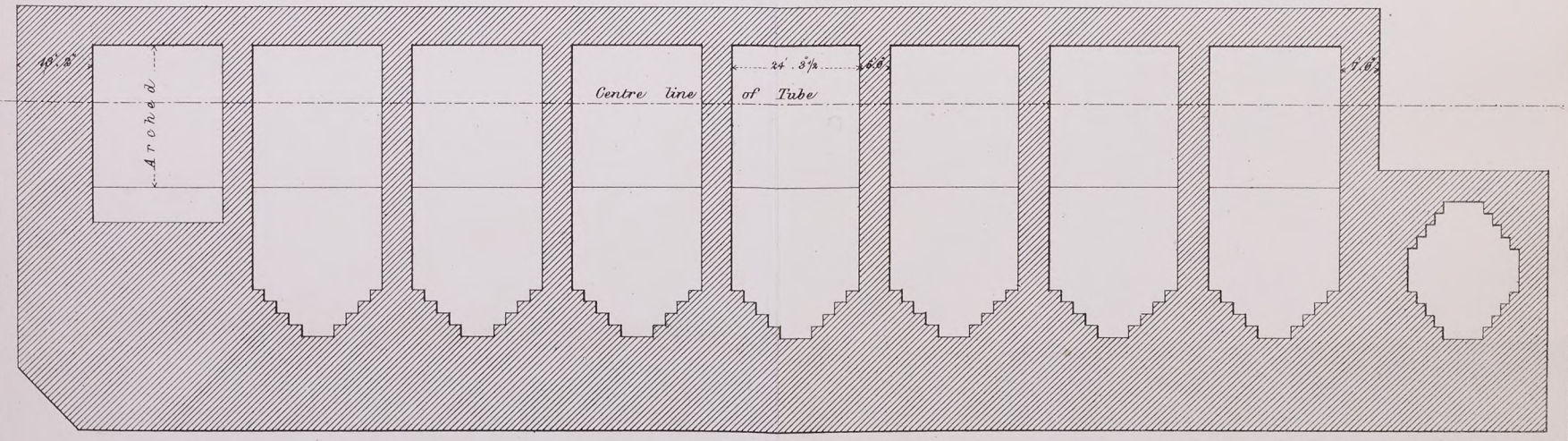


Part Longitudinal Section



Transverse Section

Plan of Abutment taken 32'. 6" below underside of Tube



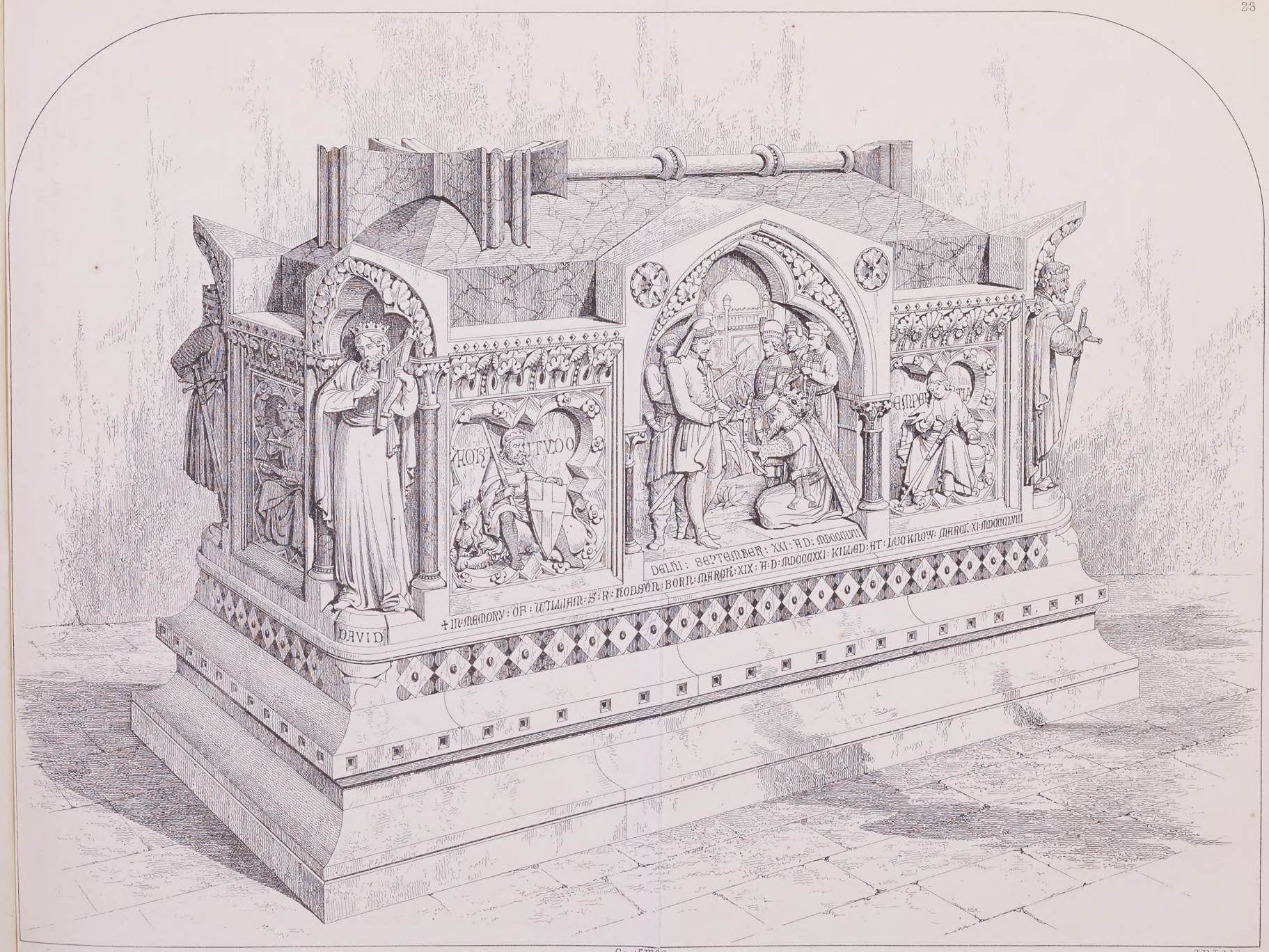
10 5 0 10 20 30 40 50 100 FEET

Augst 1860.

J.R.Jobbins.

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Sept.r 1860

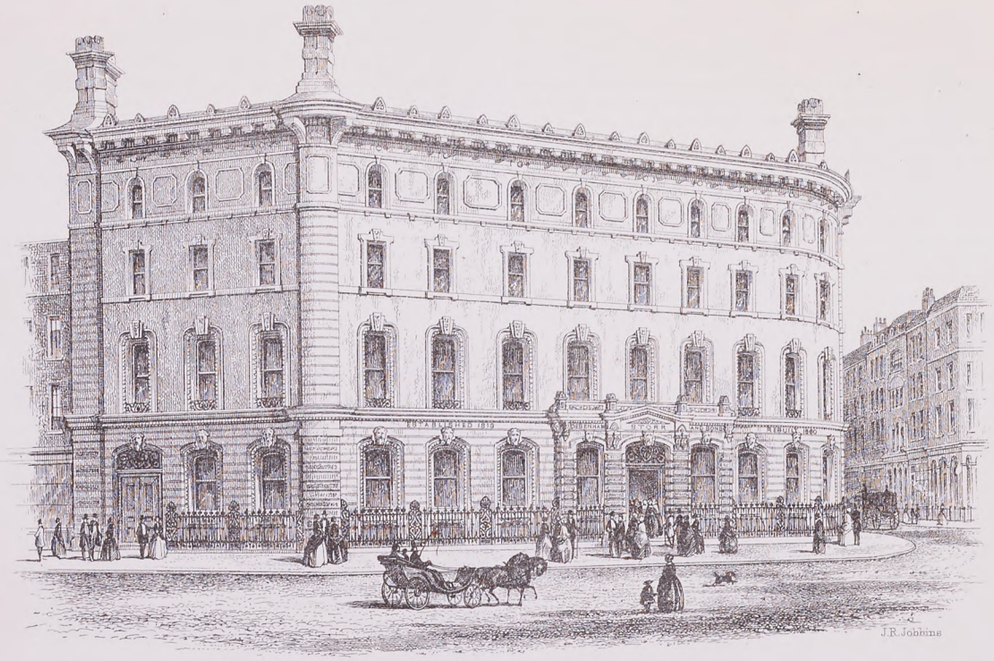
J.R.Jobbins.

MONUMENT TO THE LATE MAJOR HODSON, LICHFIELD CATHEDRAL.

G.E. STREET, ARCH.t

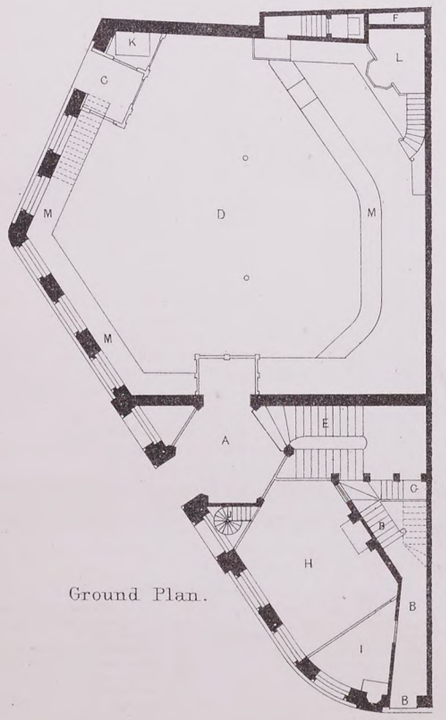
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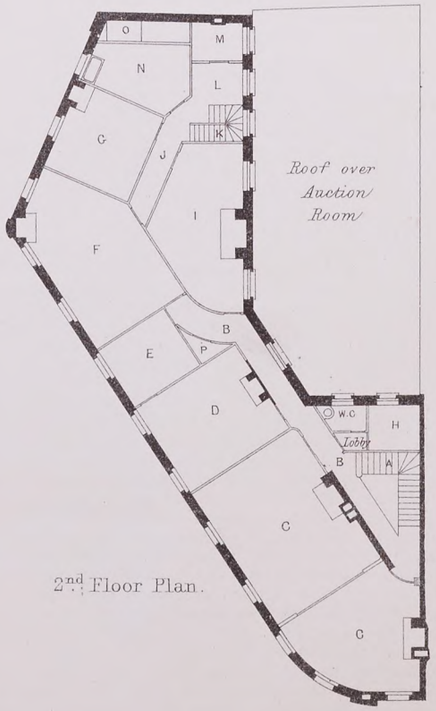


DEBENHAM STORR & SONS' NEW AUCTION ROOMS, KING STREET, COVENT GARDEN, LONDON.

Arthur Allom, Archt M.I.B.A.



Ground Plan.



2nd Floor Plan.

10 5 0 10 20 30 40 50 FEET

Sept.r 1860

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REGENERATIVE HOT-BLAST STOVES HEATED BY COAL FIRE.

Fig. 1.

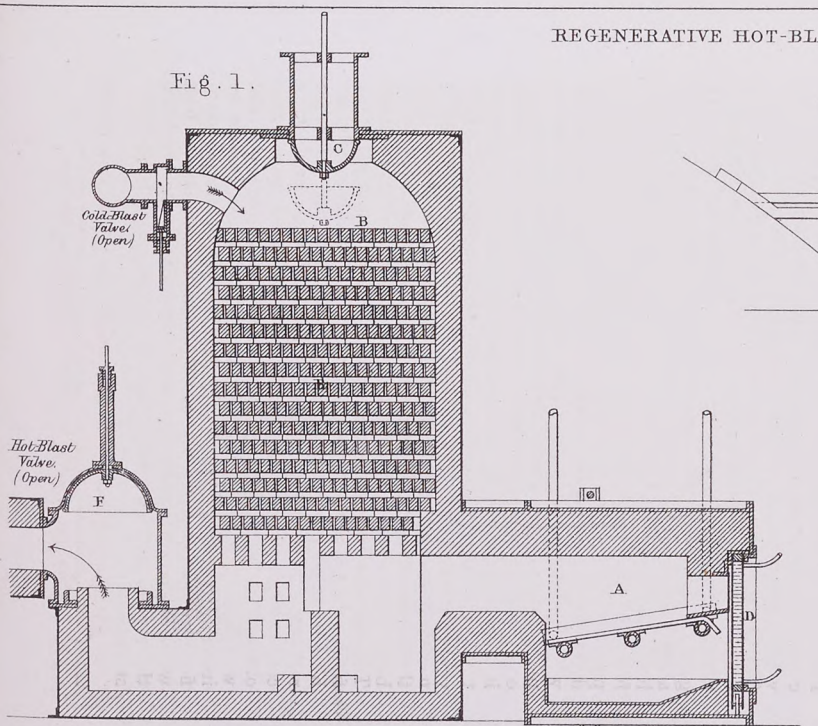
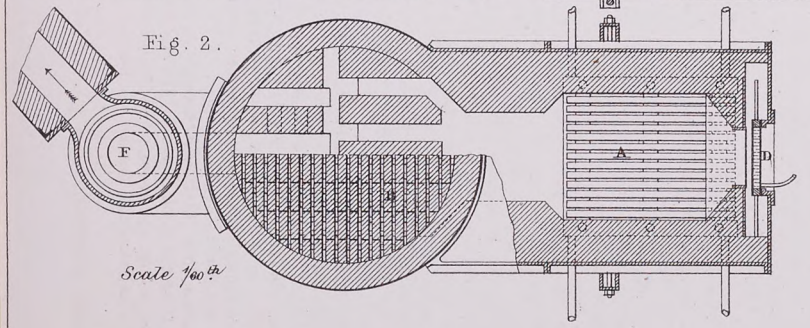
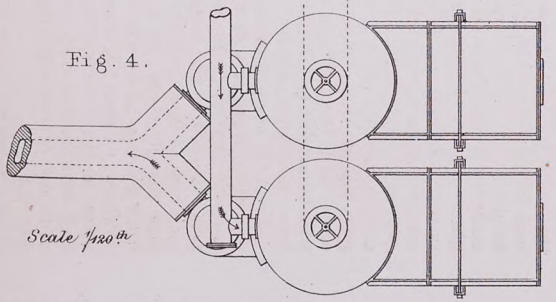


Fig. 2.



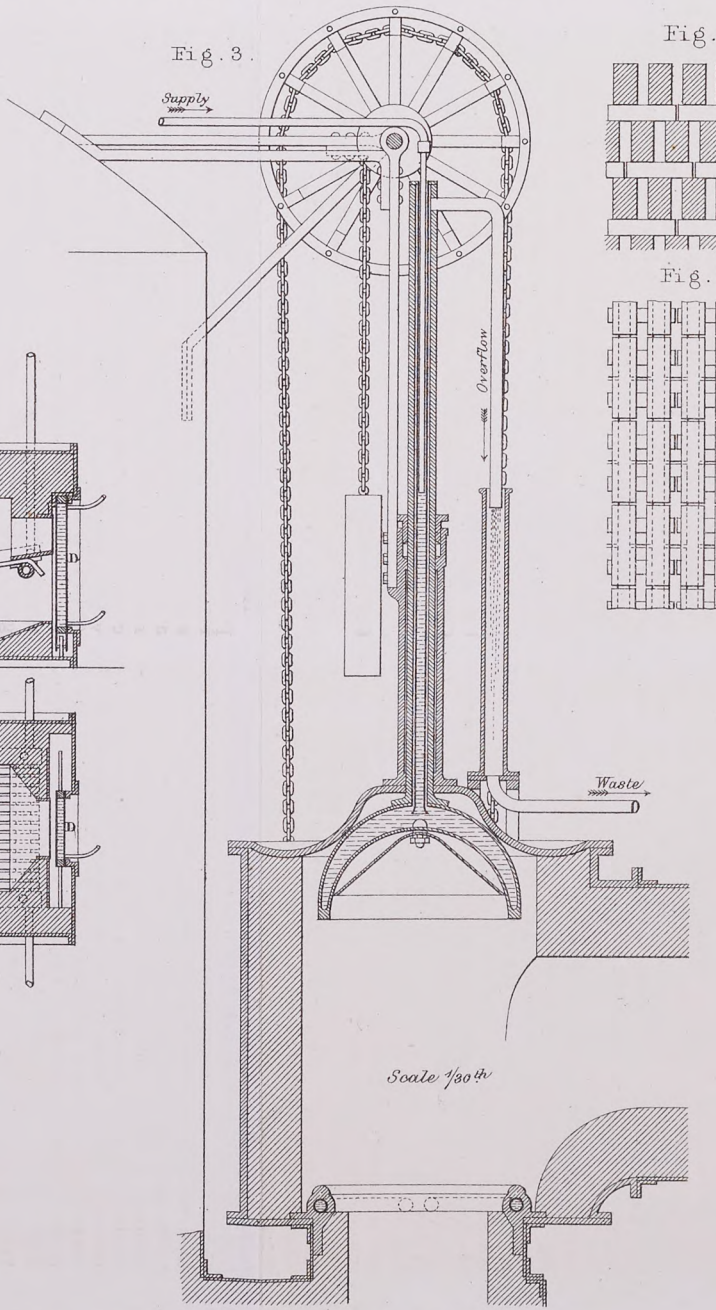
Scale 1/60th

Fig. 4.



Scale 1/120th

Fig. 3.



Scale 1/30th

Fig. 6.

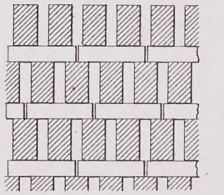
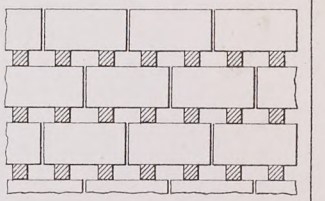


Fig. 5.



Scale 1/20th

Fig. 7.

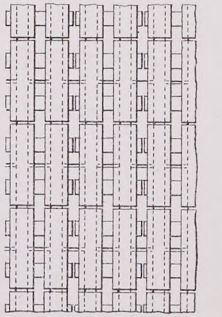
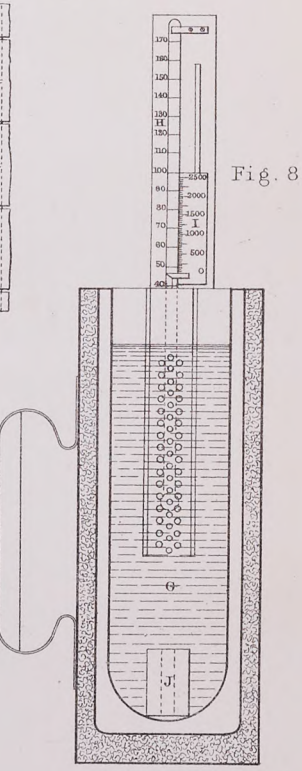
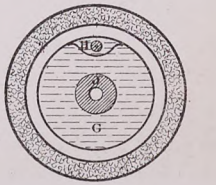


Fig. 8.



Scale 1/4th

Fig. 9.



Sept.r 1860

J.R.Jobbins.

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Oct! 1860

J.R.Jobbins

HENHAM AND WANGFORD SCHOOLS, SUFFOLK.

E.L. BLACKBURNE, ARCHT

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REGENERATIVE HOT-BLAST STOVES.

Fig. 1.

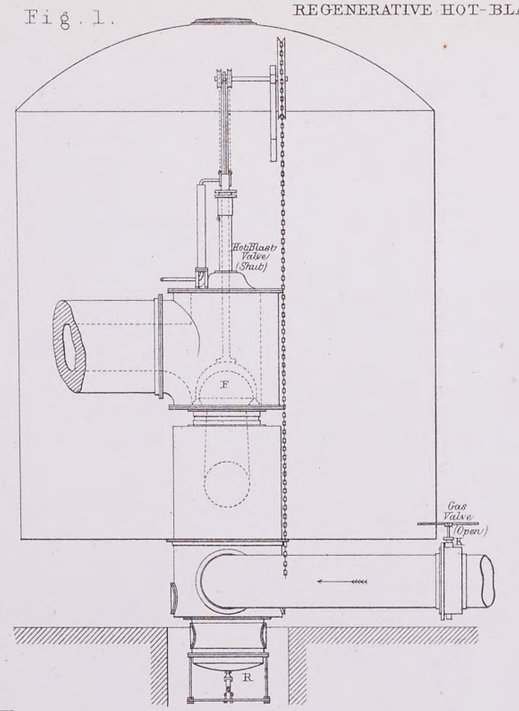


Fig. 2.

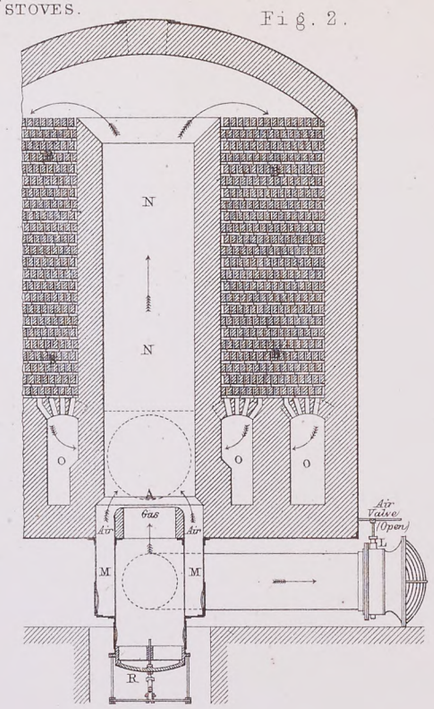


Fig. 3.

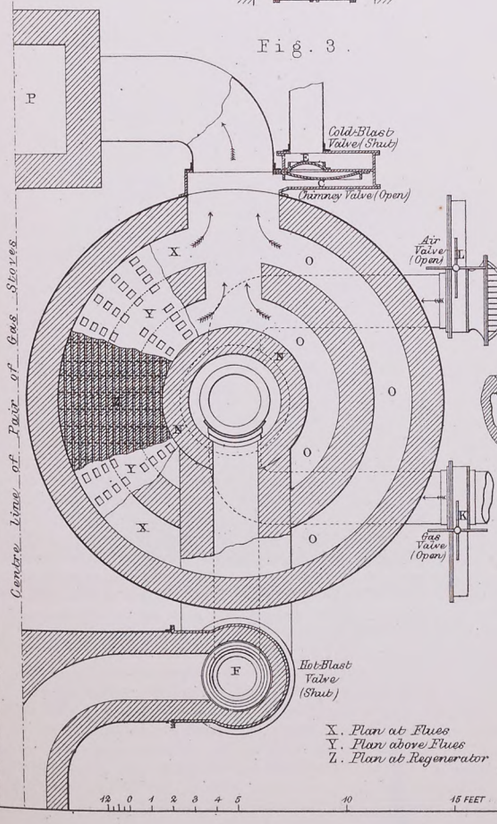
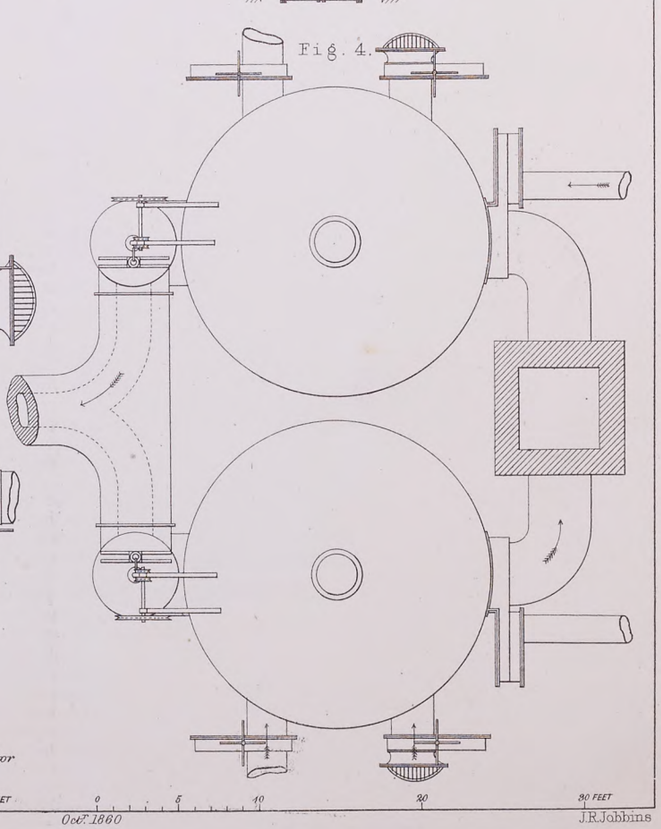


Fig. 4.



Centre Line of Pair of Gas Stoves

12 0 1 2 3 4 5 10 15 FEET 0 5 10 20 30 FEET

Oct. 1860

J.R.Jobbins

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J.R Jobbins

MARSHFIELD SCHOOLS, MONMOUTHSHIRE.

PRICHARD & SEDDON, ARCHTS



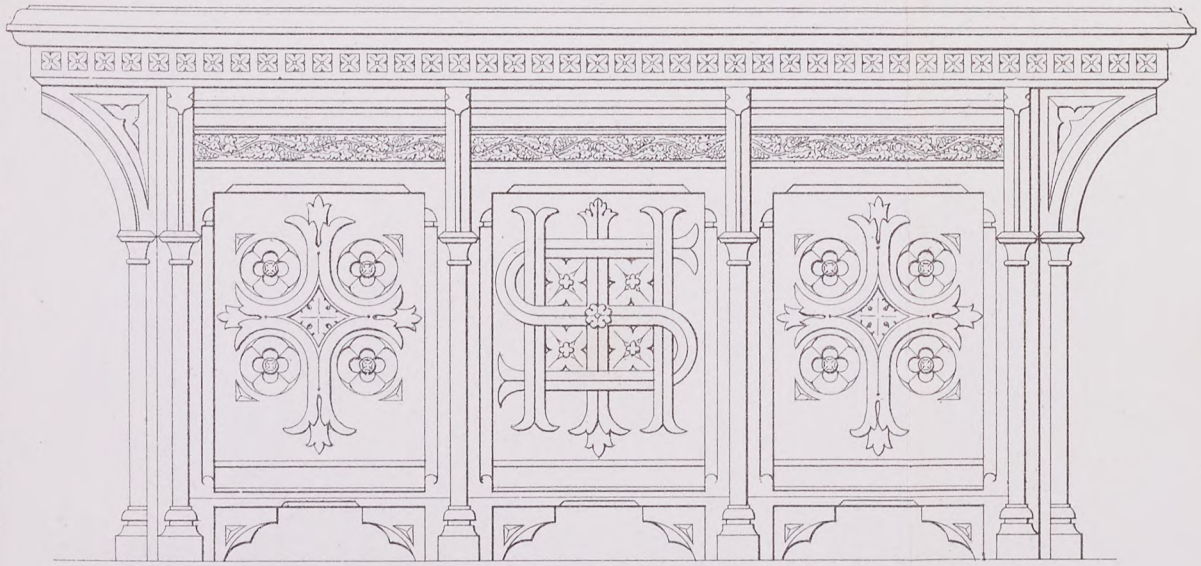
Ground Plan

Novr 1860

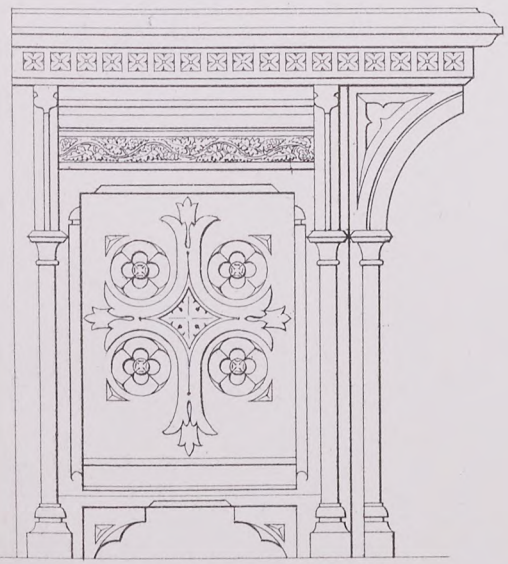
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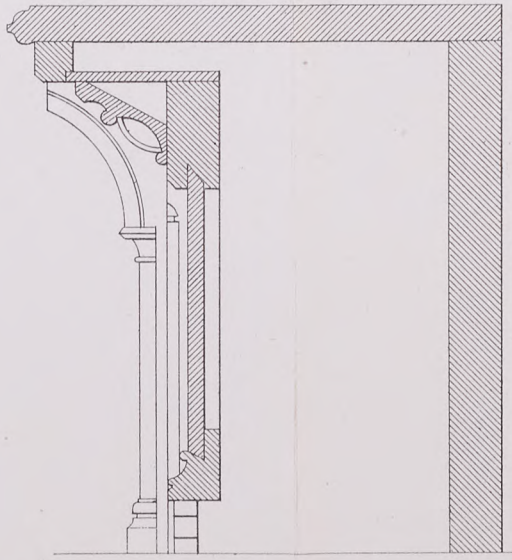
ALTAR TABLE IN MERTHYR MAUR CHURCH,
GLANMORGAN.



Elevation.



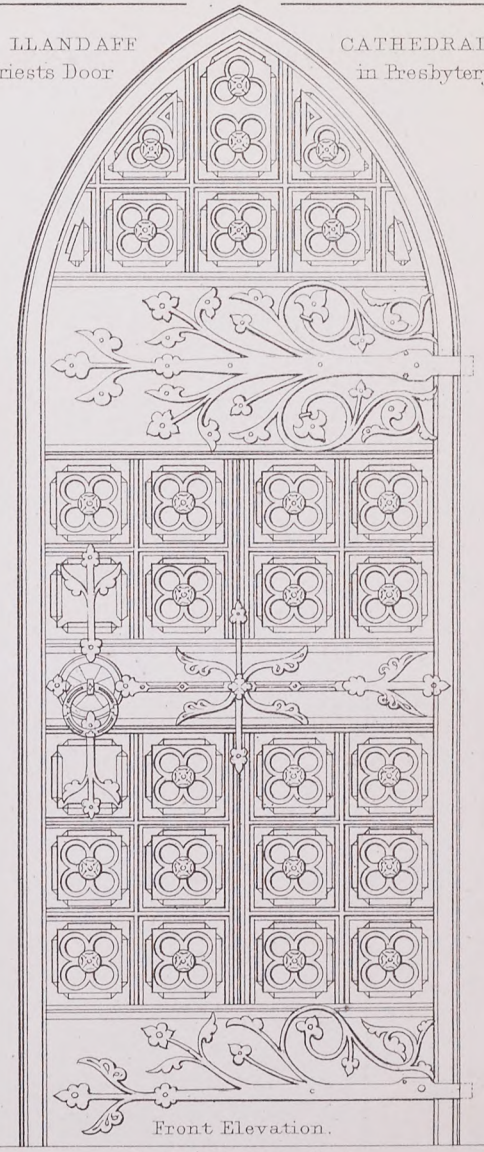
Side Elevation.



Section.

Scale 1 Inch to a Foot.

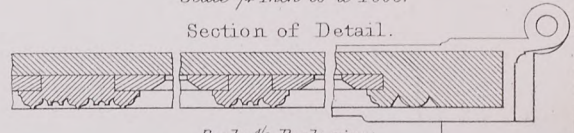
LLANDAFF CATHEDRAL
Priests Door in Presbytery



Front Elevation.

Scale 3/4 Inch to a Foot.

Section of Detail.



Scale 1/8 Real size.

Novr 1860.

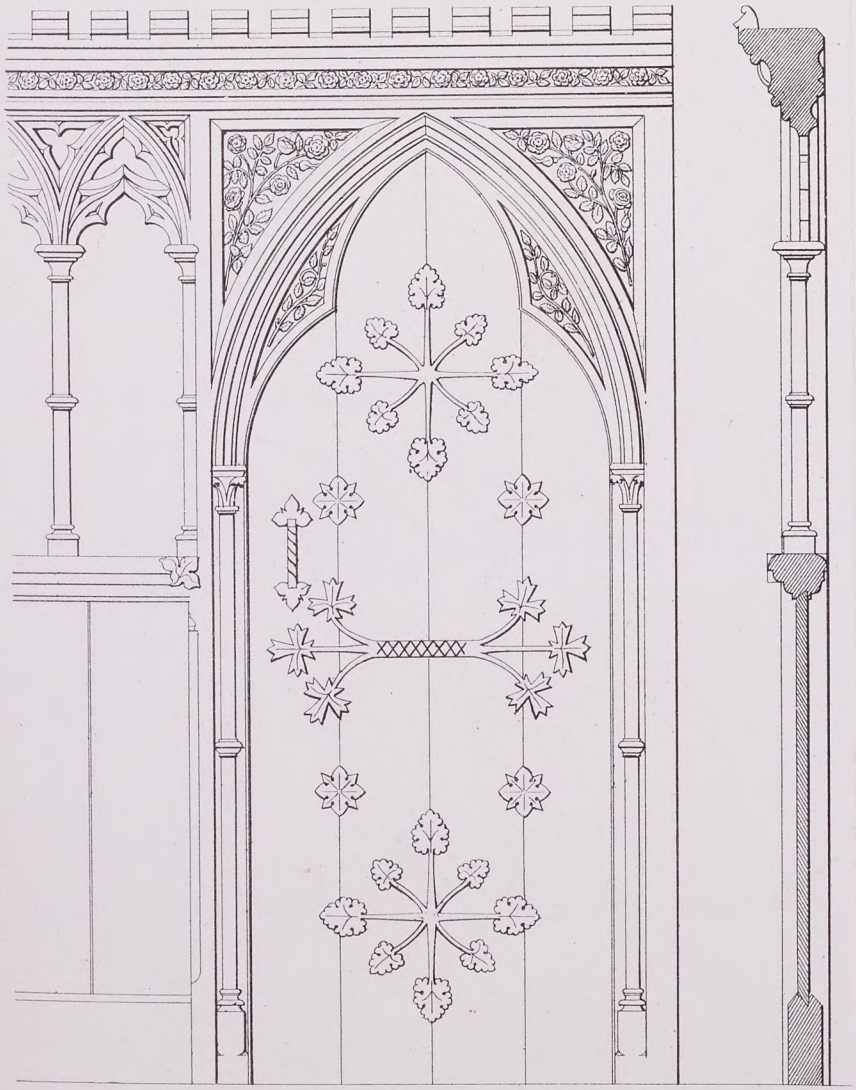
J.R.Jobbins

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CWM AVON CHURCH, GLAMORGAN.

DOOR TO CHURCH.



Elevation. Section

Plan

DOORWAY IN SCREEN OF ORGAN CHAPEL

PRICHARD & SEDDON, ARCHT.S



Half Interior Half Exterior
Elevation. Section

Plan.

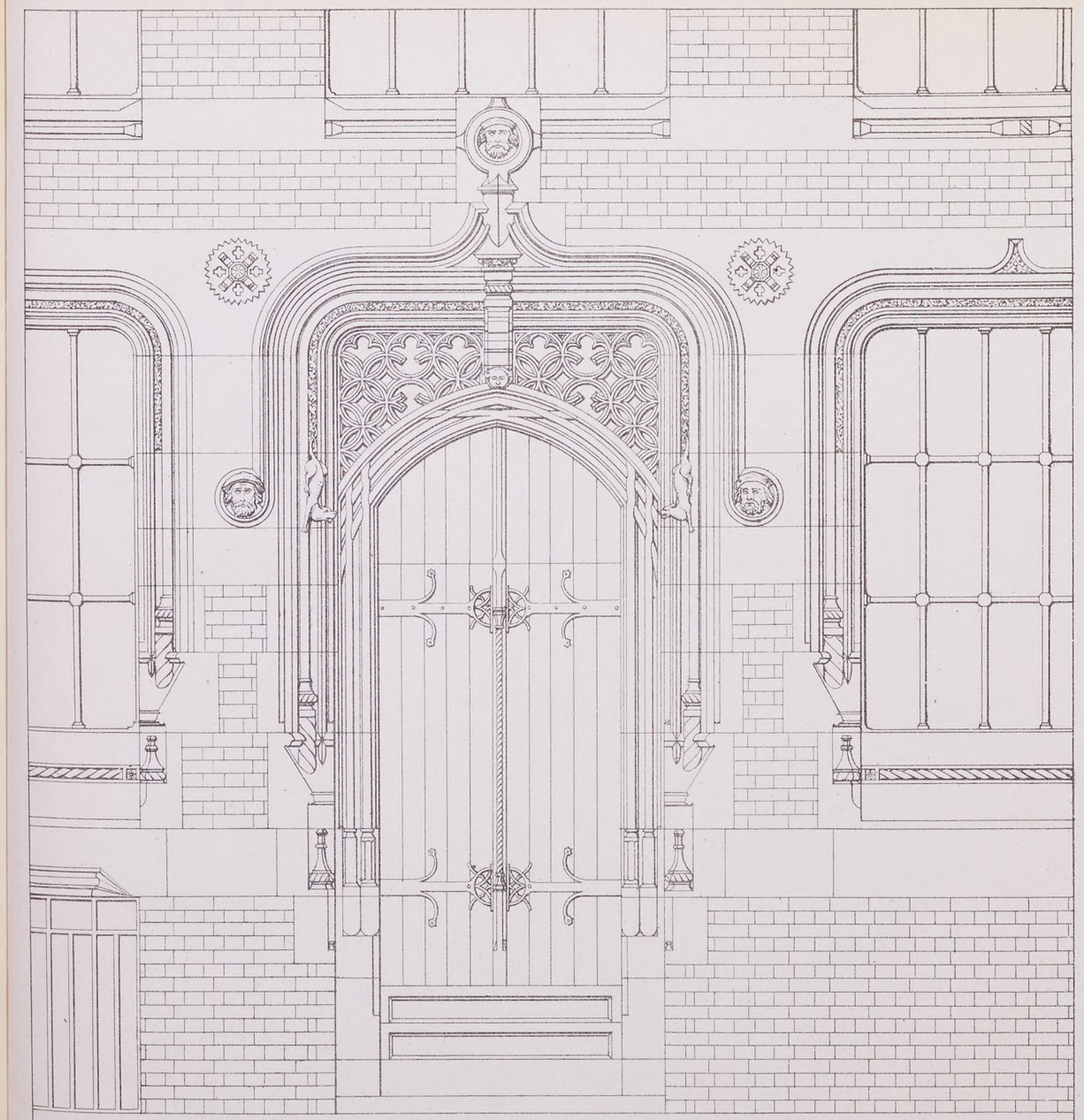
Scale ⅔ Inch to a Foot

Nov.r 1860

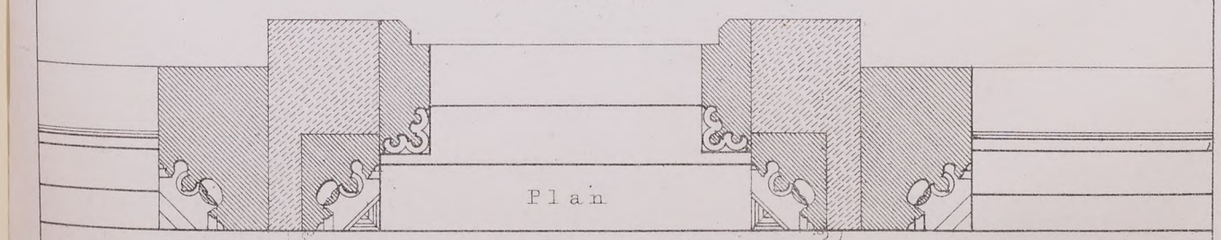
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Elevation



Plan

PART OF PRINCIPAL FRONT OF THE LONDON PUBLISHING COMPANY'S PREMISES.
10 St John Street, Smithfield.
C. SOMES CLARKE, ARCHT

12 8 0 1 2 3 4 5 10 FEET

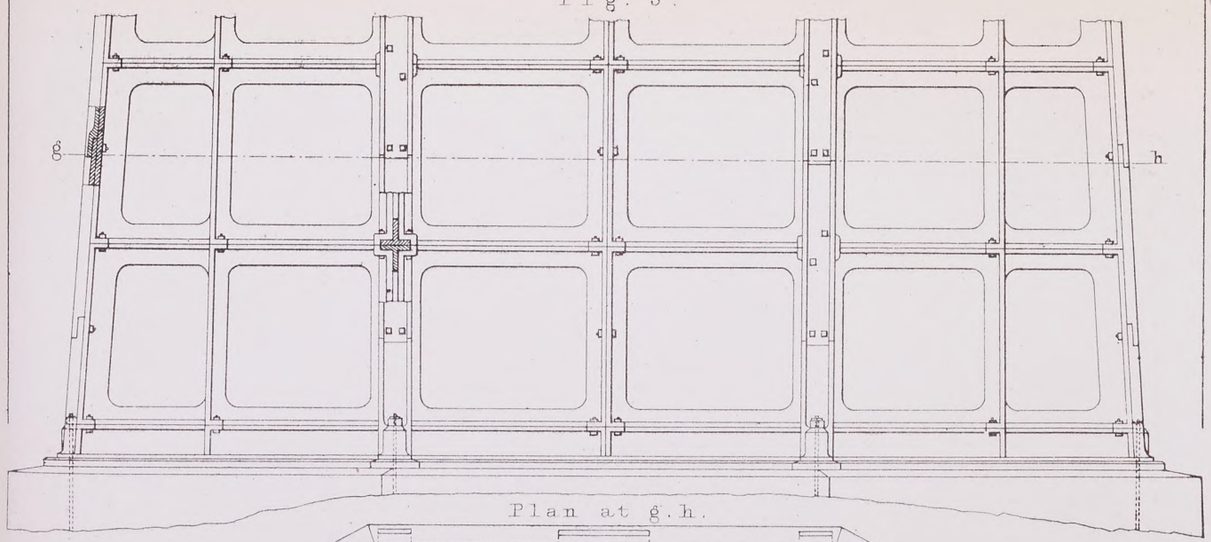
Dec.r 1860

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Fig. 3.



Plan at g.h.

Fig. 4.

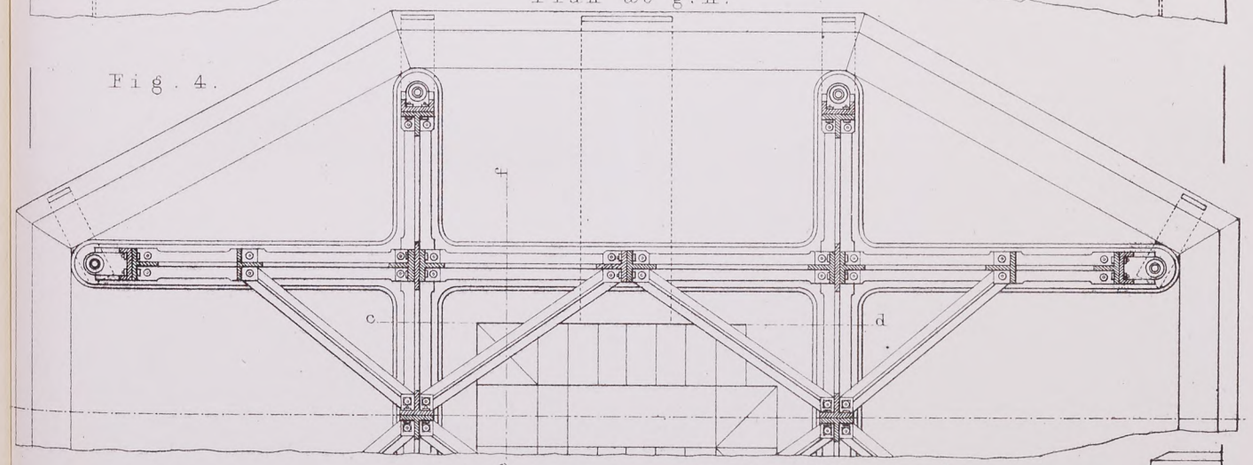


Fig. 2.

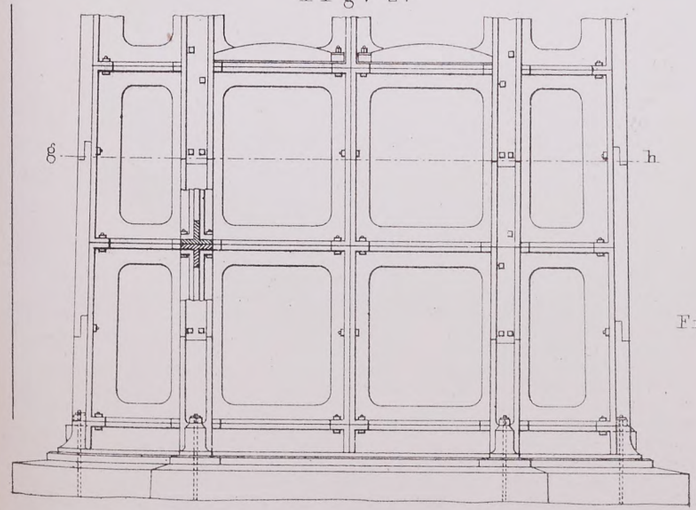


Fig. 5

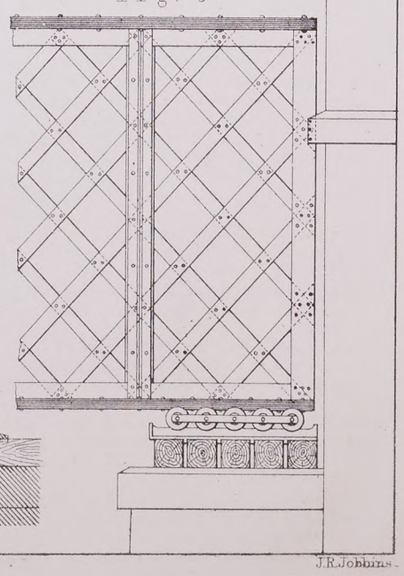
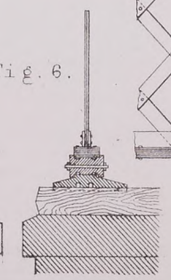


Fig. 6.



0 1 2 3 4 5 10 15 Swiss Feet

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Fig. 8.

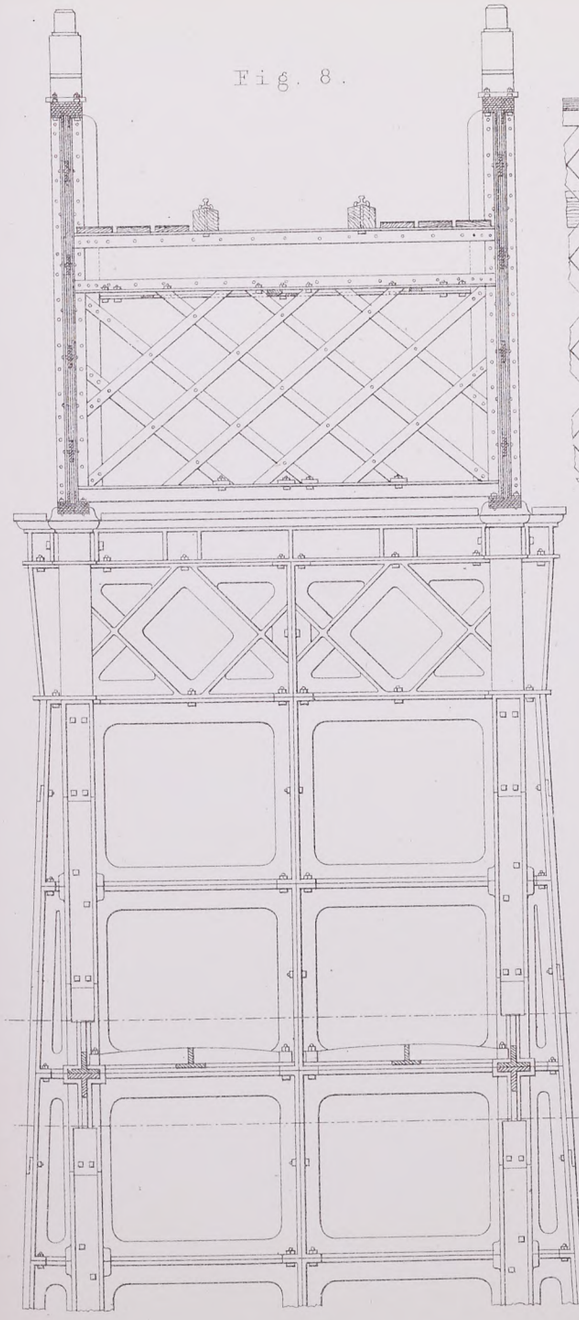
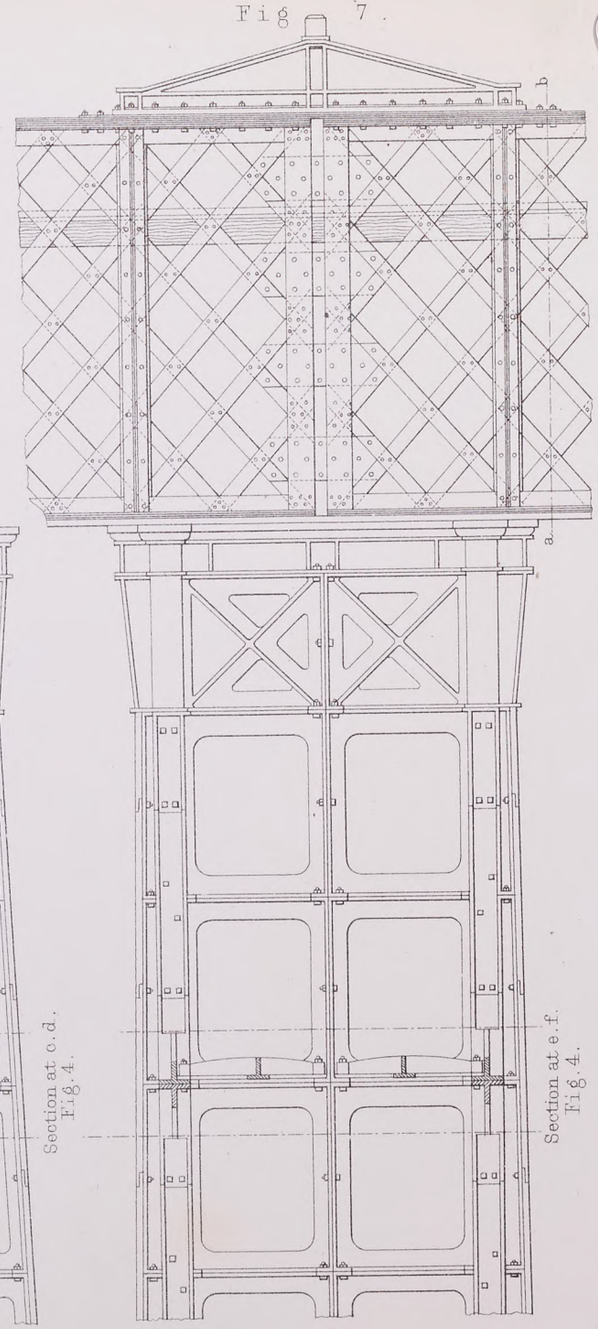


Fig. 7.

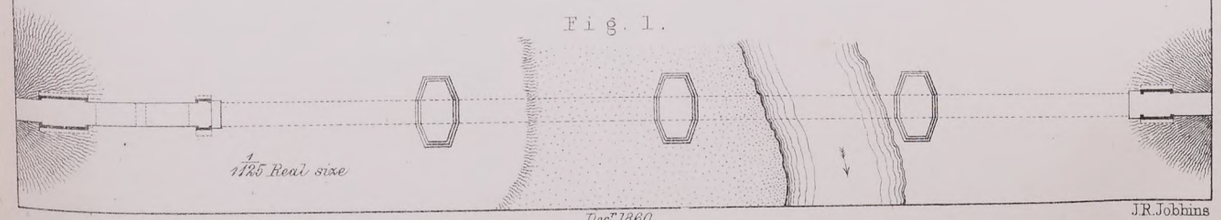


Section at c.d.
Fig. 4.

Section at e.f.
Fig. 4.

0 1 2 3 4 5 10 15 20 Swiss Feet
1/100 Real size

Fig. 1.



1/1125 Real size

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