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CONTENTS.

OWING to the great and increasing number of applications made to the editors of this journal by architects in search of assistants, and by draughtsmen in search of situations, it has seemed to them that a general want would be supplied by the establishment of a kind of architectural intelligence office in which these desultory inquiries could be filed, and timely communication opened between employers and those desirous of employment. Hitherto, it has been difficult to command the clerical labor necessary for ensuring the rapid and efficient interchange of such information throughout all parts of the country, but circumstances have improved in this respect, and the *American Architect* is now prepared to receive and register the names of draughtsmen who may be, or are likely to become, desirous of employment, and to furnish architects and engineers with information in regard to young men available as assistants. Not only draughtsmen, but persons capable of acting as superintendents are now much in demand in various parts of the country, and the latter, particularly, would find it much to their advantage to have their qualifications known; while all parties will be glad to be spared the time and trouble now necessary for making personal inquiry from place to place. In our advertising columns will be found details of the scheme proposed, and those who have occasion to make use of the facilities offered will shortly find everything prepared for their service.

SPRINGFIELD, MASS., which was one of the first cities to adopt the Holly system of steam heating, is likely to surpass its rival towns also in the matter of electric lighting. A company of citizens has been formed for the purpose of supplying light not only to large buildings and for street illumination, but for dwelling-houses. Of course, the company will be obliged to use some of the patented lamps, and a committee has been designated to visit New York and investigate the merits of the different systems. It will certainly be advantageous to have the business, at least for a time, controlled by a single company, and we may hope for interesting results from the Springfield experiment. It is worth remarking that nearly all the patentees of electric apparatus seem to have been seized lately with a kind of apathy in regard to their business in this country. The United States Company, although it is manufacturing great numbers of the Maxim lamps, is indisposed to make contracts at present for placing them in buildings, and the latest improvements of Mr. Edison and Mr. Brush have been for some time matters of rumor only. The explanation probably is that all those interested are waiting for the great Electrical Exhibition, which takes place in Paris in August, and fear to lessen their success there by a premature display of their best work. It would be well worth the while of the Springfield committee to wait another month, and make their observations in Paris, rather than on this side of the ocean. The American electricians have arranged for a very brilliant representation there, and the facilities for comparison and study of all the varieties of apparatus will be such as cannot possibly be found elsewhere.

AN interesting improvement has been made in electric lighting by substituting electrodes of iridium for the carbon pencils hitherto almost exclusively used as poles in exhibiting the voltaic arc. Iridium is only fusible in the arc from a very powerful battery, and by keeping the intensity of the current below a given point the metal can be maintained at a temperature of about four thousand degrees Fahrenheit, which is far below its melting point, though high enough to add the light of an intense incandescence to the brilliancy of the arc itself. At this temperature the iridium points remain completely unchanged, and the variations and flickerings due to the rapid wearing away of carbon pencils are entirely absent in the new light, while the constancy with which the source of the illumination keeps its place peculiarly adapts it for use in the focus of Fresnel lenses, or the parabolic reflectors which in light-houses or in similar situations take their place. The process by which the iridium, naturally a gritty and intractable powder, is formed into pencils for use in lamps is an ingenious adaptation of a patent issued long ago for making the same metal into points for gold pens; and depends upon the property which iridium possesses of forming a compound with phosphorus which can then be melted at a temperature of about three thousand degrees, — about the fusing point of iron, — and moulded into masses, which can be subsequently dephosphorized, and regain the original infusibility of the pure metal.

M. ALFRED DURAND-CLAYE, whose reputation as an engineer is probably familiar to our readers, has published a paper, originally read before the *Société d'hygiène*, upon the recent drainage works executed in certain German cities, of which *La Semaine des Constructeurs* gives a short abstract. M. Durand-Claye was invited to examine the cities of Pesth and Odessa, with a view to preparing a scheme of water-supply and drainage for them, and on his return visited Berlin, Dantzic and Breslau to satisfy himself as to the working of their peculiar sewerage systems. At Dantzic, where one of the first attempts at sewage irrigation on a grand scale was carried out a few years ago by Mr. Baldwin Latham and an associate, the result seems to have been very satisfactory. The land subjected to irrigation is sandy and absorbent, so that four hundred acres — less than one-third of the territory reserved for the purpose — is found sufficient to purify the whole efflux from a city of about a hundred thousand inhabitants. Although the climate is in winter very severe, there is no interruption to the process of absorption; the temperature of the liquid is so high as to keep the ground always unfrozen, and no harm is found to be caused to the dormant vegetation by the constant soaking. Vegetables and cereals are cultivated, a small part only of the ground being occupied for pasturage. A contractor, Mr. Aird, enjoys the use of the land rent free, and in return pays the cost of raising the sewage by pumps to the requisite height for distributing it over the territory, a matter of about seven thousand dollars a year. Since the works have been in operation, the average rate of mortality has fallen from thirty-six and fifty-nine-one-hundredths per thousand, to twenty-eight and fifty-nine-one-hundredths.

IN Berlin, where the circumstances are very similar to those at Dantzic, a comprehensive scheme of the same kind is being rapidly carried out. Street by street, the ancient vaults and gutters are summarily suppressed, and the proprietors are compelled to lay pipe drains communicating with the new sewers, all thoroughly trapped, and provided with access for inspection. The sewer system conducts the waste liquids of the city to five different points, situated at intervals around the border, and at each of these it is pumped up and distributed over irrigation fields in the vicinity. Only one of these is yet in full operation, the methods employed being similar to those in use at Dantzic and at Gennevilliers, but with one improvement, consisting in the setting apart of about one-fifth of the land for storage fallows, into which large quantities of liquid are allowed to flow at intervals, to deposit at each operation a stratum of fertilizing matter, which, when it accumulates to a foot or more in thickness, is ploughed into the soil, and in its turn cultivated. These storage basins form admirable regulators, allowing the supply of liquid to the irrigated fields to be nicely proportioned to the state of the weather and the needs of the crops. So far, the receipts from sales of vegetables cover only the cost of management, but the experiment is hardly past its first stage. At Breslau, a city of two hundred and fifty thousand inhabitants, a system of water-supply and drainage entirely similar to that of Berlin is now in process of construction. The irrigation works are under the charge of Mr. Aird, the same contractor who undertook the experiment at Dantzic, and the result bids fair to be as favorable as in that city. M. Durand-Claye closes his long and carefully illustrated account of these great undertakings by the observation that "in Germany it is everywhere agreed that the sanitation of towns rests on three principles: first, the complete abstraction of waste matters by sewers; second, the abundant distribution of water in houses, and frequent flushing of drains; third, the purification of sewage by the soil and by vegetation." Nor are these opinions confined to Germany: sixty-eight English towns now purify their sewage by irrigation; while Paris and Milan have long followed, not in the most efficient manner, a similar course. It is hardly to the credit of the United States that with the single exception of the village of Lenox, Mass., no city or town has seen fit even to investigate seriously the merits of a system which now engages the attention of the best engineers of Europe; and that when the designer of this little work shall have left us to place his skill for a time at the service of foreigners, there will be no one remaining, of any eminence in the profession, to keep us in mind of the progress made from day to day by our rivals across the sea.

The Philadelphia *Telegraph* makes some comments upon the circumstances which characterize the growth of London as shown by the last census. Although half a million of souls were added to the population of the great city between 1870 and 1880, it appears that so far from increasing at the expense of the rural districts, as is often asserted, London actually grows at a slower average rate than the other portions of the kingdom. This average is, however, the mean of considerable fluctuations. In this respect London is coming to hold much the same relation to England that New York does to the United States. If business is brisk, or other favorable circumstances exist, multitudes of people flock from the smaller towns and villages to take up a residence in the city. They remain there for a few years, and are enumerated once or twice in the census reports; then some change occurs, trade falls off, or another district becomes the scene of special activity, and a quiet transfer of population takes place to those fields where employment seems more sure or more profitable. In the Continental cities, particularly in Paris, the case is very different. To a Frenchman, the metropolis presents an attraction which cannot be overcome without a struggle, and it would be a very unusual combination of circumstances which could reverse the ordinary flow from the provinces to the centre.

A most interesting series of experiments has recently been made by Mr. D. T. Lawson, of Wellsville, Ohio, to determine the true cause of the bursting of steam-boilers. Mr. Lawson has been for some time impressed with the weakness of the theory which regards this phenomenon as due principally to the expansive force of the steam confined in the boiler. According to his reasoning, steam, being a perfectly elastic gas, increasing and diminishing in volume by regular gradations, is incapable, under any known law, of such instantaneous and enormous variations of expansive energy as those by which boilers, while running quietly at a pressure far within the limits of safety, are often, without the slightest warning, blown into fragments. An adequate source of explosive action is, however, found in the heated water, which, when the cohesion of its molecules is overcome beyond a certain point, flashes at once into a volume of vapor which under normal pressure would be seventeen hundred times larger than that of the original liquid, with an action precisely similar to that of gunpowder, but more rapid and violent. This explosion may be determined, Mr. Lawson thinks, by any sudden reduction of the pressure upon the surface of the superheated water in a boiler, such as might be caused by throwing open a valve hastily, or by the sudden condensation of a portion of the steam; and the frequency with which boilers burst at the moment when steam is turned into the cylinder confirms this view. To test his theory he had a boiler constructed six feet long and thirty inches in diameter, with a calculated resistance of six hundred and four pounds to the square inch. This was filled three-fourths full of water, and the fires lighted under it. When the steam-gauge indicated a pressure of three hundred and eighty pounds, the spectators ensconced themselves in bomb-proof casemates erected for the purpose, and from this shelter the valve intended to allow steam to flow into the cylinder was thrown open. Instantly there came a tremendous explosion, tearing the boiler and furnace into small fragments. One piece fell half a mile away; while the end of the boiler was found to have struck the side of a hill near by, ricocheting like a cannon-ball, loosening the stumps in its course, and at its last bound cutting the bark from a tall tree fifty feet from the ground.

A fatal explosion in Philadelphia a few days ago has brought to notice the fact that seven or eight hundred steam-boilers are now in use in that city which have heads of cast-iron. The one in question was of this kind, but had been inspected and certified by the agent of the Hartford Boiler Inspection and Insurance Company, which, however, did not prevent its giving way suddenly and killing three people; and the coroner's jury, after a long investigation, condemned entirely the use of cast-iron in any boiler, and called upon the authorities to take steps for prohibiting it. In this their judgment is confirmed by the opinion of one of the engineers of the Hartford Inspection Company itself, who testified that although he felt obliged to pass boilers with cast heads, since a refusal to do so would condemn a very large number of those in use, he believed it was time to have such construction made illegal. In this every one who has anything to do with steam-boilers, unless selling them, will heartily coincide. Perhaps an exception might be made in favor of the light cast-iron sectional boilers which have been for some time in use. These are virtually constructed in the expectation that they will burst sooner or later, and are so arranged that the explosion of a single section can take place without injuring the rest. In this way no great harm is likely to be done by a failure, and the fragments of the exploded portion once removed, and replaced by a new section, the boiler is as good as ever, but the substitution of a brittle and uncertain material for the proper wrought-iron of large boilers is a deception of the very worst and most dangerous character.

A grand system of underground railways is projected in Paris, and it is said that the municipality, the State, and the Department of the Seine will contribute a subvention of twenty million dollars toward the construction if the scheme is carried out. The central terminus will be in the garden of the Palais Royal, at a depth of twenty-four feet below the surface, and from that point three main lines will diverge toward the great railway stations and the principal suburban points, while a separate road will follow the south bank of the Seine. It need hardly be said that some such means of communication between the different parts of Paris has become very necessary. Foreigners, who have plenty of time for riding comfortably about the streets, can content themselves well enough with the cheap carriages, which will transport them over the long distances at an expense which seems to them small, and with a sufficient degree of swiftness and punctuality for their purposes; but for the careful and economical French, neither time nor money are things to be wasted, and swift conveyance, at low rates, is one of the things to which the Parisians have long looked forward. The establishment of the elevated railways in New York excited great interest in France, and a similar line was at one time seriously contemplated in Paris, but, as on this side of the ocean, subterranean routes seem best to meet the popular prejudice.

The tunnel under the English Channel is actually begun, the ground at the bottom of the shafts having been found so satisfactory that headings will be driven at once a mile from each side. These will be completed in about six months, and if their construction develop no unexpected difficulty, a further treaty will probably be made for the prosecution of the work in both directions until the headings meet in the middle of the Channel. The total distance is about twenty miles, and if the same rate of progress is kept up, communication will be opened between the two shores in five years. The enlargement of the gallery to the requisite dimensions, the lining with brickwork, and the provision of necessary ventilating openings will consume some years more.

BUILDING SUPERINTENDENCE. — VII.

THE gutters must next be attended to, although the specification, in calling for "gutters of No. 24 galvanized-iron, as per detail drawing (Fig. 61), running up 16 inches under slates, and to have front edge turned over a $\frac{1}{4}$ inch by $\frac{5}{8}$ inch wrought-iron bar, with galvanized wrought-iron braces every 24 inches, running up two feet under slates, and strip of four-pound lead one inch wide soldered on under side to cover edge of stone cornice," has relieved us of the severest responsibility. But, as usual, nothing on the drawings indicates the position of the six "galvanized-iron conductors" which the specification demands, and in consequence, the direction in which the gutters shall incline must be determined by the superintendent, according to his best judgment. The task is not difficult, and the gutter, which is already on the ground, having been examined and found to be in accordance with the detailed section, well formed and straight, is passed, and immediately hoisted to the roof for putting in place.

Gutters.

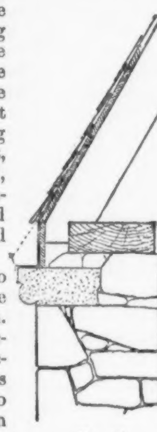


Fig. 61.

Meanwhile, we descend to the basement, to inspect the construction of the piers and the setting of the iron column in the society-room. Hardly have we turned our steps in that direction when, as we try to call to mind the basement plan, a misgiving seizes us, which is increased as the foreman mason comes out to meet us, and jerking his thumb in the direction of the society-room, begins, "About that ar column, — do you think one is enough to hold that floor?" We make no direct answer, preferring to wait until we can understand all the circumstances, which prove to be anything but reassuring. The total length of the girder in the ceiling of the society-room, from the brick wall which stands under the chancel steps to the east wall, measures forty feet, and the column is indicated on the plan as standing under its centre. The clear distance from the centre of the pillar to the wall in each direction is therefore twenty feet, spanned by a single 8″ x 12″ hard-pine timber. The floor-beams are all in place, but the shores set up at random under the girder to support it while the piers were being built have not yet been removed, so we are unable to judge by the deflection of the sticks whether they are overloaded or not. It is, however, very easy to determine this point by calculation. The girder F X (Fig. 62) carrying the western part of the society-room ceiling is the most strained, since it bears one-half the weight of the rectangular portion A C B D of the chancel floor, while the girder X E carries only one-half the semicircle C E D, whose area is but about four-fifths that of a rectangle of equal length and breadth, and we will therefore make our estimates for the timber F X, sure that if this is strong enough for its purpose, the one at X E will be more than sufficient. The distance F E being 40 feet, and the width of the cap of the column at X, 8 inches, being deducted from the total clear span of the two girders, leaves 19 feet 8 inches as the length of each between bearings. The distance A B is $39\frac{1}{3}$ feet, so that the total floor area bearing on F X is equal to $\frac{19\frac{2}{3} \times 39\frac{1}{3}}{2} = 387$ square feet. The chancel floor is to be tiled, and the weight of the floor, including beams and boarding, brick foundation and tiles, may be taken at seventy-one pounds per square foot, and that of the plastering on the under side at ten pounds more, making eighty-one pounds.

Calculation of Girder.

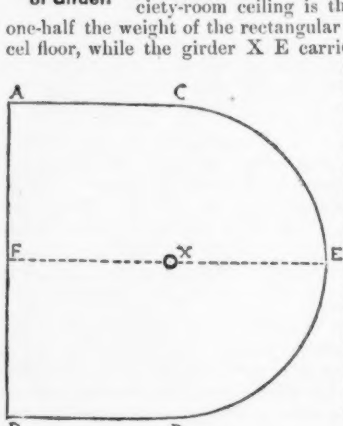


Fig. 62.

Besides this load, the supporting timber must be calculated to bear safely the weight of any probable crowd of persons upon it. By the New York building law, the load which must be assumed as thus liable to be brought upon the floor of a place of public assembly is estimated at one hundred and twenty pounds per square foot, independent of the weight of the structure itself, and though this is probably rather a high estimate of the weight of a compact crowd, we shall do best to adopt it as a standard. Our chancel floor must be reckoned then at $81 + 120 = 201$ pounds per square foot, and as the girder supports 387 square feet, the load will be $201 \times 387 = 77{,}787$ pounds, equally divided by the beams over the whole length of the girder. To this must be added the weight of the girder itself, which at 45 pounds per cubic foot will be 590, making a total of 78,377 pounds. The absolute breaking weight, applied at the centre, of a Georgia-pine beam is calculated by multiplying the breadth in inches by the square of the depth in inches, and this product by 550, and dividing the result by the length in feet, or, if

b = the breadth in inches,

d = depth in inches,

l = length in feet, $\frac{b\ d^2 \times 550}{l}$ = breaking weight at the centre.

If the load is *equally distributed*, instead of being applied at the centre, twice as much will be required to break the beam, or $\frac{b\ d^2 \times 550 \times 2}{l}$ = breaking weight if uniformly distributed. As, however, timber deflects seriously and permanently long before the load on it reaches the breaking point, and as it becomes weakened by undue strain or other causes, it is considered unsafe to load it with more than one-third the calculated breaking weight, so that the result of the operation indicated in this second formula should be divided by 3 to obtain the safe distributed load; thus,

$$\frac{b\ d^2 \times 550 \times 2}{3\ l} = \text{safe distributed load.}$$

Applying this to our present beam, whose breadth is 8 inches and its depth 12, the length being $19\frac{2}{3}$ feet, we find that $\frac{8 \times 144 \times 550 \times 2}{3 \times 19\frac{2}{3}} =$ 21,478 pounds is the utmost distributed weight which can safely be put on it. As our calculations have just shown that it is liable to be called upon to bear 78,377 pounds, there is a very evident necessity for doing something to strengthen it. What steps should be taken is a matter for the architect to decide, and we notify him at once. There are several methods to choose from. Additional columns can be interposed between the central column and the walls; or the girders can be replaced by stronger ones, leaving the single column in the centre; or additional rows of girders can be put in, each supported by columns. While awaiting his reply we will inspect the brick piers which support the girders in the main cellar. Of these there are rather more than is necessary, the plan showing them spaced but six feet apart from centres. A few only have been built, of well-formed hard brick, twelve inches square, as the plan shows, but with joints of a suspicious gray-blue color, instead of brown. They have been completed some three days, but we find that a knife-blade easily penetrates the mortar after the outer crust is pierced. Calling the mason, we ask him if the piers were laid in sand and cement, only, without lime, as the specification required. He answers with considerable hesitation that "a *little* lime might perhaps have been put in, but it is mostly cement." Our suspicions are not allayed, and we ask to see the cask from which the cement was taken, and to have the mortar mixer brought before us. The foreman is about to disappear in search of these witnesses, but we detain him and send a boy in his stead, who does not return; and after a good deal of writhing, our captive confesses, being confronted with the soft mortar, that there was no cement on the ground at the time, and he had had the piers built with the best mortar he could possibly make with the materials at hand.

Brick Piers.

"What did you color the mortar with, to make it so dark?" we ask; and the foreman replies, "Well, we didn't suppose you would know the difference, so we sent over to the grocery store, and got some lampblack, and mixed it in."

We impress upon his mind our objection to such tricks by ordering all the piers demolished in our presence, and dismiss him with an admonition.

The architect is at a distance, and before his answer about the girders arrives we have an opportunity to inspect the roofing work again. The gutters are on and properly braced, the flashings finished behind one gable, and far advanced on another, and slating has begun. The slates have but just arrived, and we stop to inspect them. The specification describes them only as "good black slate," but in the lot delivered, and stacked near the hoisting tackle, we observe several different varieties. Some are thin, but with a beautifully smooth, shining surface, and very black: these are from Pennsylvania, and are of excellent quality; others from Maine are split a little thicker, and are also smooth and shining, but with a grayish lustre, like black lead; others again are thick, with a dead look, and crumble at the edges on being strongly pinched. We take one of the last-mentioned kind, and set it up on edge in a pail of water, leaving it a few minutes, when the moisture is seen to rise in the substance of the stone half an inch or more above the surface of the water. This slate is therefore absorbent and bad, and must be wholly rejected, while, as it would give a ragged look to see two kinds used together on a roof, we summon the contractor and request him to choose between the Maine or the Pennsylvania slate, either of which will be acceptable, and send away all others.

Slate.

Ascending now to the roof, we reach the gable wall, behind which the roofer is inserting his flashings. As we approach, he hastily bundles together a quantity of pieces of zinc and throws them behind him, but the appearance of the work gives no cause for suspecting anything wrong. The lead is smoothly turned into its reglet, and the groove filled with cement; the soldering is well done, and the lower edge at the proper distance from the roof, and all closely dressed down to the stone-work. We take a convenient stick, and turn up the edge of the lead cap far enough to be able to inspect the flashing beneath. Instead of extending up the wall to within half an inch or less of the reglet in which the capping is inserted, it is turned up only about an inch and a half, so that the cap just covers the edge.

Turning to the abashed roofer for an explanation, he says that he saw no necessity for turning flashings up eight inches, which would be the distance between the roof surface and the reglet: that two inches was enough for any one, etc. We do not stop to argue the question, but simply direct the cap to be turned up throughout its length, the under flashing to be replaced in accordance with the orders first given, and the whole left exposed for a second inspection before the lead cap is turned down again into its place. Taking the roofer with us, we make our way to the other gable, where both upper and under flashing prove to be of the requisite width, but the lead, instead of being cemented into the groove, is wedged in with slips of wood. We have these replaced with slate chips, and the groove filled with fresh cement; then look to see if the tarred felt which is being spread over the roof under the slate is flexible, and the rolls perfect, instead of being, as sometimes happens, full of holes and flaws, and the material itself brittle and rotten. A glance is sufficient to satisfy us in these respects, and our duties are over for the day.

A letter received from the architect before our next visit explains the unfortunate oversight in relation to the girders in the ceiling of the society-room. It seems that three columns had been indicated in this room to support the line of girders, dividing the length into four spans, for which the timber would have been sufficiently strong, and the estimate had been made including this arrangement, and the contract signed in accordance with it. Immediately after the signing of the contract, however, the rector of the church had represented to the architect the inconvenience which would be caused by the row of pillars through the middle of a room devoted to so many uses, and had engaged him to reduce the supports to a single central column, strengthening the girders sufficiently to compensate for the increase in their length. As time pressed, the architect had hastily erased two of the columns from the tracing of the basement plan sent to the contractor for commencing operations, leaving only the single central one, fearing that any delay might cause useless foundations to be put in for the pillars first shown, and intending to arrange for the substitution of iron beams, or girders strengthened in some other way, for those specified; but this had slipped his mind until he received our letter. As a considerable saving in cost was effected by omitting the two iron columns, a corresponding allowance would have to be made from the contract price, to be offset against the extra cost of strengthening the girders. Just how this should be effected he did not wish to dictate positively. His own idea had been to substitute two rolled-iron beams, placed side by side and bolted together, for each of the wooden girders, but this would be exp n ive, and although he was not restricted as to the cost of making the change desired by the rector, he would like to save the church all needless expense, and if we could devise any cheaper mode of trussing the present girders, or otherwise supporting the floor, he would leave the matter wholly to our judgment, in which he had great confidence. The girders, he would remind us, were intended in any case to be plastered over.[1]

In accordance with the instructions contained in the letter, we set ourselves to devise, if possible, an inexpensive mode of trussing the girders to which it relates, and thereby fulfil the architect's wishes by saving the cost of iron beams. Some further calculations will be necessary to test the expedients which occur to us. The present girders have been proved to possess only about one-fourth the requisite strength. The most natural way to increase this would be to add other timbers beside the original ones. If four girders of equal size with the one we have were placed side by side, and all bolted together, so that any burden on one would be resisted by the combined strength of the four, the problem would be solved, but in a very awkward manner, since the cap of the single column would have to be dangerously extended in order to support the ends of all the girders.

Perhaps this might be obviated in another way. Recurring to the formula for transverse strength of beams, we notice that while the resistance increases *directly* as the breadth of the timber, it is augmented in proportion to the *square* of its depth, so that although a single beam of four times the strength of one girder, and of the same depth, would need to be four times as broad, a beam equally strong would be formed by a timber of the same breadth, but of only twice the depth. As our present girder is 8 inches broad by 12 inches deep, a stick 8 inches by 24 would just meet our wants.

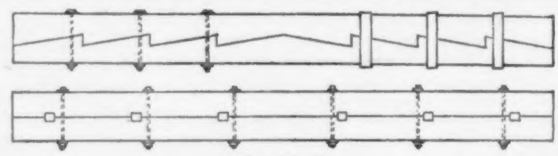
Unfortunately, it is impracticable to procure beams of such dimensions, and we must try some other expedient. It would be of no avail to put a second 8 x 12 girder below the first; each of them would bend independently of the other, and their united strength would be that of two beams only, instead of four.

Iron might be employed for strengthening the wooden sticks. A strip of boiler plate, 12 inches wide and half an inch thick, might be bolted on each side of the present girder, strengthening it perhaps sufficiently; or rods might be used to form a "belly-truss" (Fig. 63), the strength of which would depend mainly on the depth which could be given to it.

This would, however, cause an unsightly projection into the room, which must be furred over to conceal it, and the trussing, though cheaper than the flitch-plates, would still be somewhat costly.

Fig. 63.

Reflecting upon all these devices, it occurs to us that if a second beam similar to the present one could be placed below it and strongly connected with it, so as to constitute practically one timber, the desired result would be attained in a form extremely compact and simple. Turning to some text-books which we have brought with us, we learn that this can to a limited extent be accomplished by bolting or strapping the two pieces together, and either indenting them into each other as in Fig. 64, or notching them and inserting



Figs. 64, 65.

hard-wood keys, as in Fig. 65, the sole object of the indentations or keys being to prevent the slipping of the contiguous surfaces of the beams upon each other, so that in order to bend, the *whole* of the lower part of the compound beam must be stretched, and the whole of the upper part compressed, just as if the beam were in one piece (Fig. 66), instead of the upper and lower halves of each stick undergoing their own separate compression and extension, as in Fig. 67, which shows the action under stress of beams superposed, but not keyed together.

Figs. 66, 67.

The books inform us that compound beams so keyed together and tightly bolted are nearly equal in strength to a solid stick of the same dimensions, bearing in mind that the depth of the indents or notches for keys must be *deducted* from the total depth of the two timbers in order to obtain the effective depth which can alone be used as a factor in calculating the strength.

This expedient may furnish us with a resource, but we find on careful study that if eight keys were used, which would be a sufficient number, the depth of each would have to be within a small fraction of four inches, two inches being cut out of each timber; and in order to obtain a net depth of 24 inches, which is what calculation shows to be necessary for the strength which we require, the aggregate depth of the two sticks before cutting must be 28 inches. Hence, as the one already in is 12 inches deep, the other must be 16 inches. A 16-inch Georgia-pine timber happens in this place to be difficult to obtain, the stock sizes running only to 14 inches; so, after a thorough study of the matter, we are induced to search for some still further means of so combining the two beams as to secure the whole substance of the lower one for resisting tension, and of the upper one to resist compression, the essential requisite for enabling the compound girder to act as a single timber.

Calling to mind the construction of certain bridge trusses, in which the upper chord is brought completely into compression and the lower one into tension by means of inclined struts, which resolve the downward pressure upon them into a push with their heads in one direction, and with their feet in the opposite direction, and being arranged so that half of them point one way and half of them the other, mutually act to compress the upper and to stretch the lower chord with their united force (Fig. 68), we reflect that if similar means could be applied to two superposed beams, the result might be just what we desire.

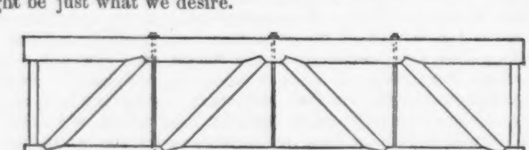


Fig. 68.

The action of the oblique struts in the bridge can be applied to the compound beam in the simplest possible way by nailing oblique pieces of board firmly to the timbers, reversing them on opposite sides, in imitation of the reversed struts in the bridge truss (Fig. 69). If these boards are $1\frac{1}{4}$ inches thick, their united strength will be

[1] The writer feels as if he owed an apology to his imaginary architect for exhibiting him as guilty of so many mistakes and oversights, but he is anxious to impress upon the minds of his readers the lesson that an efficient superintendent should be able to criticise and correct in good time, if necessary, the work of the architect, and to act in his stead upon occasion. His ability to do so will not be likely to make him over-forward in thrusting himself into the other's place, while it may save the latter infinite trouble and anxiety. For this reason the writer represents his architect as neglectful and ignorant, solely for the sake of showing the way in which the good superintendent can bring him out of his errors with credit, or, if both offices are united in one person, how the architect can extricate himself from them. It must be remembered that our hero, whatever he may be called, can only give proof of his varied ability by being furnished with occasions for exhibiting it.

greater than that of either of the beams, and if well nailed, so as not to spring, the lower beam will be torn apart before they will yield. The nails, if long enough to penetrate three inches or more into the girders, can only give way by shearing, which would require a force greater than would be necessary to break a solid beam. The strength of a girder built up in this way will not be affected by shrinkage, which soon causes more or less deflection in those indented or keyed together; for its resistance is maintained by the board struts, which act only in the direction of their length; and this remains invariable whatever may be the lateral shrinkage.

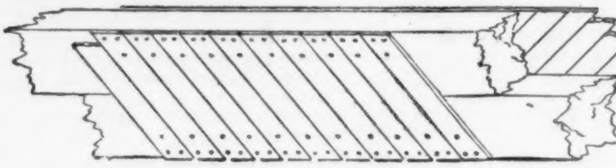


Fig. 69.

As a compound beam of this sort is a novelty in construction, we do not venture, although the theory appears satisfactory, to apply it to the important case before us without testing it by models. Two or three of these are quickly made, at one-eighth the size of the real girder, the two sticks which we propose to combine into one being accurately cut out of Georgia pine, each 1 inch wide by $1\frac{1}{2}$ inches deep. At the same scale with the other dimensions, the length, to represent the length of the real girder, would be about $2\frac{1}{2}$ feet, but if our theory is correct, even the small model, if cut so short as this, would require a distributed load of nearly 4,000 pounds, or a centre load of about 2,000, to break it. We can, however, reduce the transverse strength by adding to the length, and if this is made 10 feet, or four times that first proposed, the centre breaking weight will be approximately 500 pounds, — $\frac{1}{4}$ of the first result. This is quite within our reach, and we cut off the sticks at 11 feet length, set them one above the other, and put on each side slips of any wood at hand, a little more than $\frac{1}{8}$ inch thick, set at an angle of 45° with the top of the beam, and nailed with small brads, about $\frac{5}{8}$ inch long, three in each end of each piece. These very well represent the spikes to be used in the real beam.

Setting up two trestles, with triangular pieces put on top so as to give supports exactly ten feet apart, we hang a "scale," or platform suspended by ropes, which is used to hoist bricks or other materials to the centre of the model beam, first weighing it accurately. Before going farther, posts must be set up in pairs, enclosing the model beam between them with just enough room to allow it to deflect freely. This is to prevent the beam from turning over on its side, which so small a stick is liable to do under a centre load. Then bricks are piled on the scale, weighing each one before adding it.

The centre breaking load of a solid Georgia-pine beam 1 inch wide, 3 inches deep, and 10 feet long, is 495 pounds: that of two sticks each 1 by $1\frac{1}{2}$ inches, by 10 feet, superposed, but not connected, would be $247\frac{1}{2}$ pounds. The strength of our model cannot possibly exceed the former, but should, if our reasoning is correct, approach it. As the weights are placed one by one in the scale, we add up the total load, and experience a lively interest as the stress upon the beam begins to approach four hundred and fifty pounds, without any sign of giving way. The deflection is considerable, and the model is evidently under severe strain, so, to avoid the shock caused by the placing of a brick on the pile, we increase the load more gently by pouring on weighed portions of sand. Four hundred and fifty pounds are passed; then four hundred and sixty; and little by little the weight approaches four hundred and seventy. Just as this point is reached, a warning crack is heard, and we stop; but nothing further follows; we recommence pouring, but before another pound is added, the beam yields, letting the scale drop suddenly, and on examination the lower stick of the combination is found to be torn asunder. No change whatever is observed in the board struts.

The second model breaks at four hundred and seventy pounds, and a third at four hundred and seventy and a half. Comparing these with the calculated strength of a solid beam, we find that the girder built up by our simple method proves to possess a strength about equal to ninety-five per cent of that of a solid beam of the same breadth and depth; a result superior to that obtained by indentations, or keys and bolts or straps, and at a fraction of the expense. The carpenter, who had viewed our preparations with an ill-concealed scorn for "them little slivers," is profoundly impressed at the resistance which the slender model displays, and respectfully listens to our directions as to the mode of trussing the larger beams. A very simple calculation only is needed to show that if the strength of one 8" x 12" girder of the given length is sufficient to carry safely 21,478 pounds, as previously ascertained, a solid beam of equal width, but twice the depth, would carry four times as much, namely, 85,912 pounds, and that if for the solid beam of 8 by 24 inches a compound girder were substituted, built up of two superposed 8 by 12 sticks in such a manner that it possessed ninety-five per cent of the strength of a solid beam, this built-up girder will sustain safely 81,616 pounds. As the load upon our floor with 120 possible pounds of humanity per square foot added, and including the weight both of the girder now in place, and the new one added beneath it, will be but about 79,200 pounds, this construction gives us assurance of success, and we hasten to put it into execution. As the compound beam thus made forms virtually a lattice truss of which the upper and lower chords are in contact, its strength, like that of all trusses, could be increased by *separating* the beams, so as to make the depth of the truss greater, and in this case the side struts should be stronger in proportion to the longitudinal timbers. Our girder is, however, strong enough, and more compact than a truss. It is quite important to gain all the room possible beneath the girder, as well as to have it rest properly on the cap of the column, so we will, after shoving up the ends of the beams on each side, cut off the portion which overlaps the girder, and after this has been reinforced with the second stick, and the boards nailed on, the compound beam can be pushed up between the ends of the joists flush with their top, and these will then, instead of resting directly on the girder, be supported by strips of wood 2" x 4", spiked to the girder on each side over the board struts.

Having made careful notes of the quantity of extra timber used for the new trussed beams, and of the time occupied in cutting out, making over and replacing the work, in order to adjust the cost subsequently, we turn to look at the lining wall of the room, which is being built up inside the stone-work. As this wall is to be plastered, care must be taken not to "strike" the mortar joints off flush with the surface of the brickwork, thus taking away the projections needed for the plaster to cling to. The common way of reserving a proper "key" is to leave the mortar irregularly projecting, as it is squeezed out of the joints when the bricks are hammered into place with the trowel; but many builders find that the annoyance caused by the occasional projection of the dried mortar beyond the line of the plastering is so great that they prefer to lay the horizontal joints full of mortar, striking them off smooth, but to lay the vertical joints "slack," that is, only partly filled with mortar, so as to leave cavities into which the plaster can penetrate and obtain a firm hold.

The lining wall is often built before laying the floor-beams, which rest on this, and not on the main mass of masonry; but, although a four-inch brick wall, well tied to a thicker one behind it, possesses surprising strength, the unusual weight of the tiled chancel floor makes it desirable to support the beams which are to carry it on the heavy outside wall. In the tower vestibule, however, there is no objection to resting the timber ceiling on the lining wall, which, being of face-brick, will not be built until near the completion of the structure, to avoid marring it.

The piers are next inspected, and prove this time to be well built, of bricks properly soaked in water, and laid with cement mortar. One or two are crooked or out of plumb, and we order them to be taken down and rebuilt; and in a few instances chips of wood have been used as wedges between the top of the piers and the girders, which, as they would soon shrink and allow the floor to shake, we have replaced with stone chips or slate and cement.

The church at our next visit is a maze of scaffolding, put up for the use of the plasterers, and furring is rapidly going on. The upright studs against the walls are all in place, and spiked as strongly as may be to the masonry. Some builders rake out a joint, and drive in a wedge-shaped piece of wood for nailing the furrings to, and others build "wood bricks," or short bits of joist, at intervals into the walls, for the same purpose; but such pieces are very apt to shrink so much as to become loose, while the driving of wedges may endanger the stability of the wall, so that the practice of driving the spikes directly into the mortar is generally preferable. Very rarely the joints are raked out and slips of lead laid in, the spikes being driven between these, but the gain is hardly worth the expense. At all events, it is desirable and usual to stiffen the upright furrings by angular bridging (Fig. 70), in the same manner as a partition.

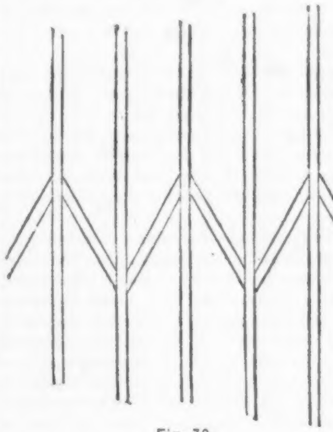


Fig. 70.

Some precautions should at this stage be taken to lessen the dangerously inflammable quality of this light construction. As all those experienced in fires know, the furring studs set against the walls of stone structures form lofty flues of inflammable material behind the plastering, up which the flames run with incred-

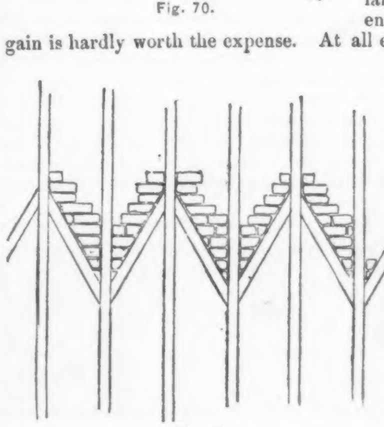


Fig. 71.

ible rapidity, urged by the strong draught which can at all times be felt rushing up through them, and a small fire originating in the basement of such a building usually breaks out immediately in the roof, where it is uncontrollable. The means for preventing this, and confining an accidental fire within the limits where it can be reached and extinguished, are extremely simple: a single row of bricks laid in coarse mortar on the floor between the furring studs will cut off the communication between the cellar and the space behind the plastering, so that a fire catching in the basement from spontaneous combustion of coal, proximity of smoke-flues or furnace-pipes to wood-work, or any other cause, is compelled, for want of access to the concealed passages behind the furrings, to burn through into the room, where it may blaze for hours without doing much harm, and is easily quenched with a few pails of water. Two rows of bricks are still better than one, and the only precaution to be observed is to fill up the *whole* space from the stone wall to the inside finish, — wainscoting, sheathing, plaster or baseboard, —with the mass, so as to leave no openings. If a second barrier of coarse mortar and chips is laid on top of the bridging (Fig. 71) all around the building, it will be doubly protected, and its destruction by fire will be rendered slow and difficult.

THE ILLUSTRATIONS.

DETAILS OF A HOUSE ON COMMONWEALTH AVE., BOSTON, MASS. MR. J. P. PUTNAM, ARCHITECT, BOSTON, MASS.

COMPETITIVE DESIGN FOR FURNITURE OF A HOTEL BEDROOM, BY MR. W. J. MARSH, WASHINGTON, D. C.

"'*Morpheus*' comes boldly charged with inspiration from English interiors. The perspective suggests a library conceived in the style of the late Mr. B. J. Talbert rather than a hotel bedroom, but it is drawn with spirit and skill, and presents an attractive apartment. To be sure, its air of 'solid comfort' is rather exaggerated, that expression not meaning of necessity the massive comfort here shown; for the details, though good in design, are far too heavy and clumsy throughout. For instance, the spindles at the foot of the bedstead approach the vigorous proportions of the legs of the bed. The upper part of the toilet-table is out of keeping with the rest."

SCOTTISH SKETCHES BY MR. J. W. SMALL, F. S. A. SCOT: — STREET VIEW, CULROSS, SCOTLAND; WALL PANELLING AT CULROSS.

HEAT IN ITS RELATIONS TO BUILDING APPLIANCES.

THE remarkable phenomenon which we call heat plays too important a part in the economy of nature to allow of its being overlooked by those who are engaged in the operations of building, since the strength, form, and utility of many substances are greatly affected by variations of temperature. In the present article we propose to consider some of the effects which these changes of temperature produce upon building materials and building operations generally, so far as they have been determined by careful and well authenticated experiments and investigations.

The first thing we have to consider is the mode of measuring with accuracy the changes which occur in the temperature of a body. This is done for moderate degrees of heat by means of an instrument called a thermometer, in which the expansion or contraction of a fluid such as alcohol or mercury indicates an increase or diminution in the amount of heat which a body contains. In this country we have two standards in use for measuring variations of temperature, one of which, called the Fahrenheit scale, is in common use for every-day purposes, and has the temperature of melting ice, commonly called the freezing point of water, indicated by the arbitrary number 32°, that of boiling water being 212° when the barometer stands at 30 inches, the space between these two points being divided into 180 equal divisions called degrees. The other system, called the centigrade scale, which is now universally used for scientific purposes, takes the melting point of ice as the zero or 0°, and the boiling point of water as 100°, the space between them being divided into 100 equal parts or degrees. Thermometers made of glass, and containing either alcohol or mercury, are incapable of being employed for very high temperatures, since the former boils at 78° centigrade, and the latter at 320°, so that we must use some other means for measuring higher temperatures than these; the same standard scales are, however, adopted, whatever the temperature may be. If we put F for any number of degrees on the Fahrenheit scale. and C for any number on the centigrade, we can find by the following equations the number of degrees Fahrenheit answering to any given number of centigrade degrees, or of centigrade corresponding to any number of degrees Fahrenheit.

$$F = \frac{9}{5}C + 32, \qquad C = \frac{5}{9}(F - 32)$$

The table given below will also show the relation between the two scales for some of the more important temperatures; but throughout the present article we shall always use the centigrade scale in speaking of temperature, unless otherwise stated.

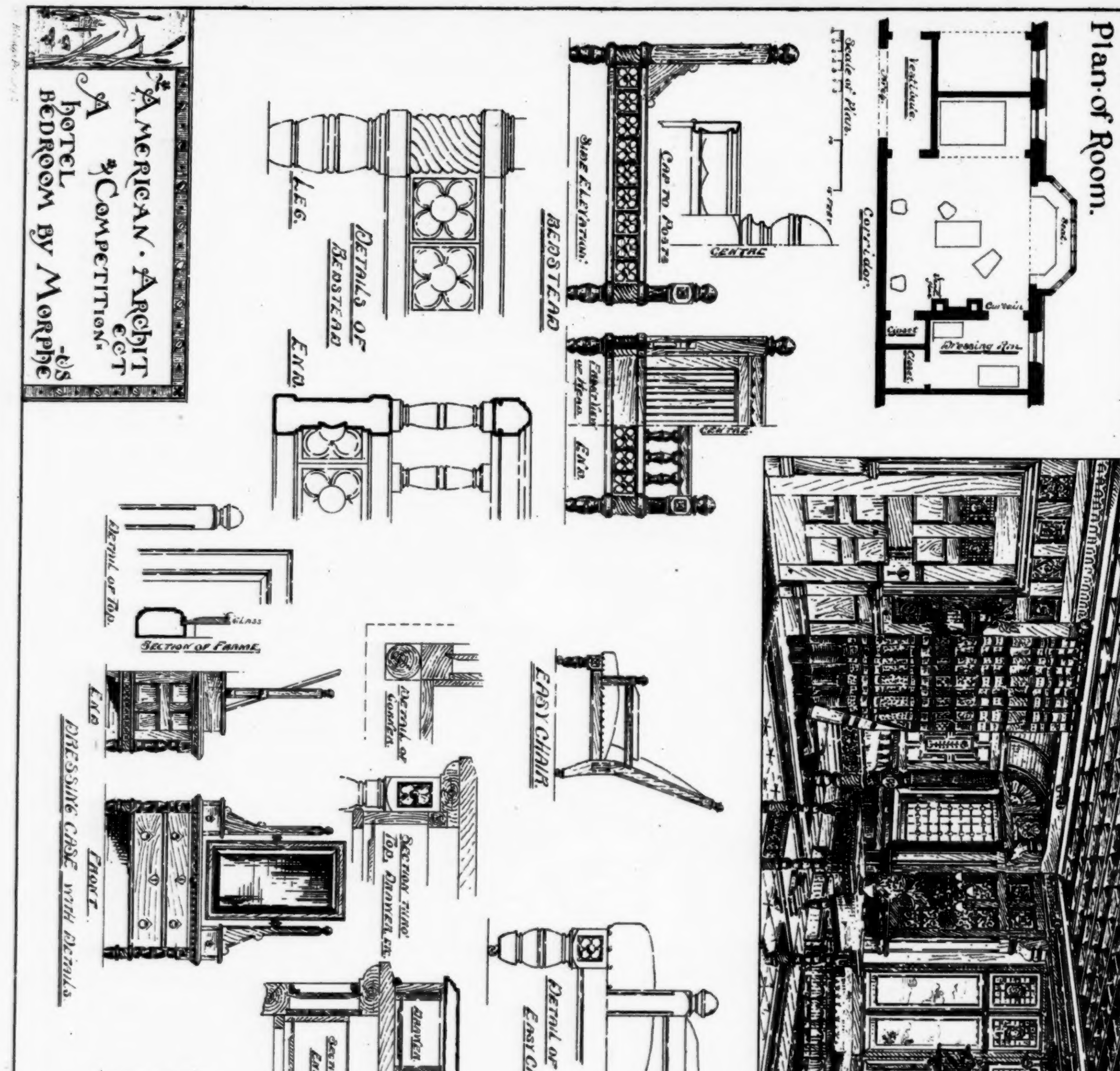
One of the most important phenomena to the builder is the effect produced upon water by change of temperature, since this is a substance that enters largely into many kinds of building materials. It is an *almost* universal law that bodies expand in volume as their temperature rises, and contract as it falls; and we find that water follows this law between the temperatures of 4° and 100°, so that the same weight of water which at 4° occupies exactly one cubic foot of space, or 1,728 cubic inches, will be found at 50° to occupy 1,749 cubic inches, and at 100° a space of 1,803 inches, the *rate* of expansion increasing with the rise of temperature. The contraction is also in an inverse ratio as the temperature falls, 1,728 cubic inches of water at 100° occupying only 1,656 inches at 4°. Here, however, the contraction ceases, for we find that as the temperature falls below 4° the water expands as much for each degree below as it did for each degree above 4°; consequently the temperature 4° is that at which water has its greatest density, and 1,728 cubic inches at 4° occupy 1,728¼ at 0° or zero of centigrade scale. At this point, however, a sudden change occurs, the liquid water becoming solid ice, and at the same time expanding instantaneously about 10 per cent in bulk, so that 1,728 cubic inches of water at 0° are converted into 1,904 cubic inches of ice at the same temperature. The force developed by this expansion at the moment of congelation is the same as would be required to compress a given quantity of water by one-eleventh of its bulk. Now the pressure of 15 lbs. on a square inch of water is found to produce a compression of one-twenty-thousandth of its bulk; therefore the force per square inch required to compress it by one-eleventh must be equal to $\frac{20000}{11} \times 15$, or 27,273 lbs., or about 12 tons for every square inch of surface. This, then, may be taken as the actual force exerted by the congelation of water, and as it takes place very suddenly, the effect produced by converting water in a closed vessel will resemble the blow of a hammer of 12 tons weight upon every square inch, so that we cease to wonder at the bursting of the strongest pipes if full of water when congelation takes place. Newly-quarried blocks of stone, if exposed to frost, will be split to pieces by the freezing of the moisture which they contain. Blocks of slate are also rendered more fissile by the action of frost, and can be readily split into thin layers; but should a thaw follow the frost, it will be found very difficult to split them until a new frost sets in and restores the faculty of splitting. If, however, the blocks of slate are exposed to a succession of frost and thaws, they become quite unsplittable. Mortar or cement joints which have been newly made, when a frost comes will be seriously affected by the freezing of the water they contain, and will fall to pieces.

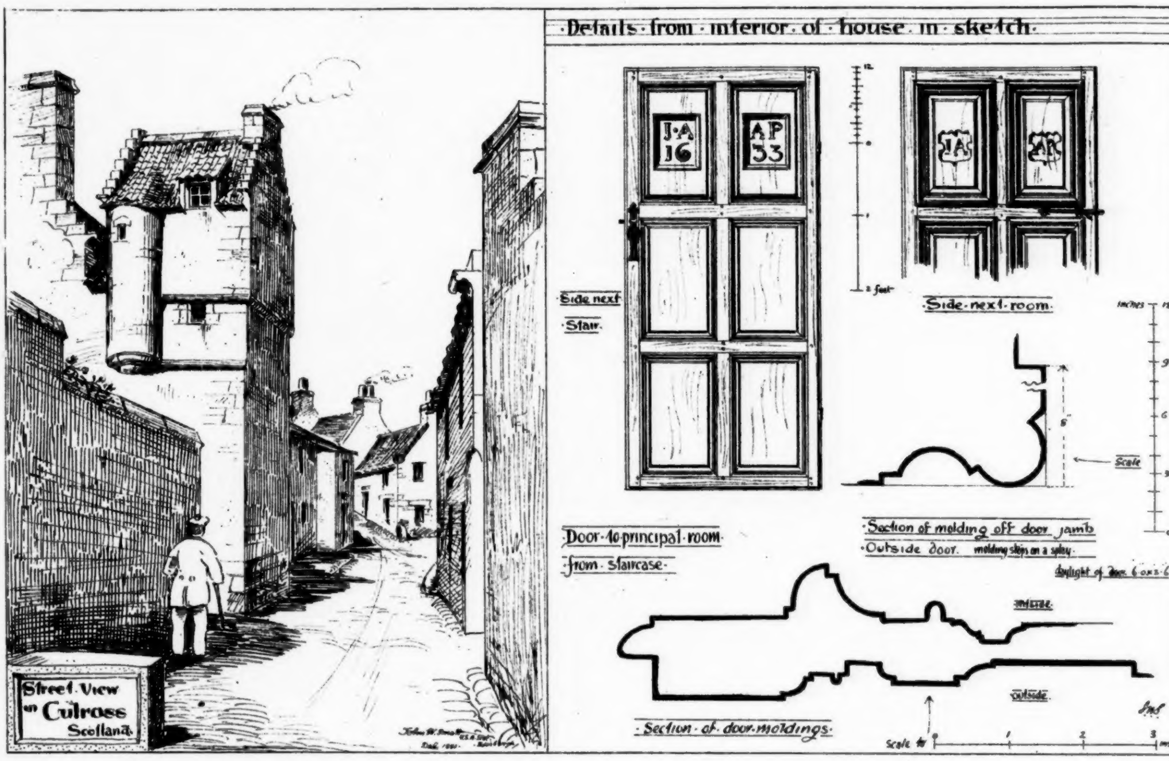
Fahr.	Cent.	
0°	—17.78°	
32	0	Ice melts.
39.2	4	Maximum density of [water.
61	13	
172	78	Alcohol boils.
212	100	Water boils.
455	135	Tin melts.
608	320	Mercury boils.
633	334	Lead melts.
773	412	Zinc melts.
1652	900	Strong red heat.
1994	1090	Copper melts.
2372	1300	White heat.
2732	1500	Cast-iron melts.
3092	1700	Steel melts.
3452	1900	Wrought-iron melts.

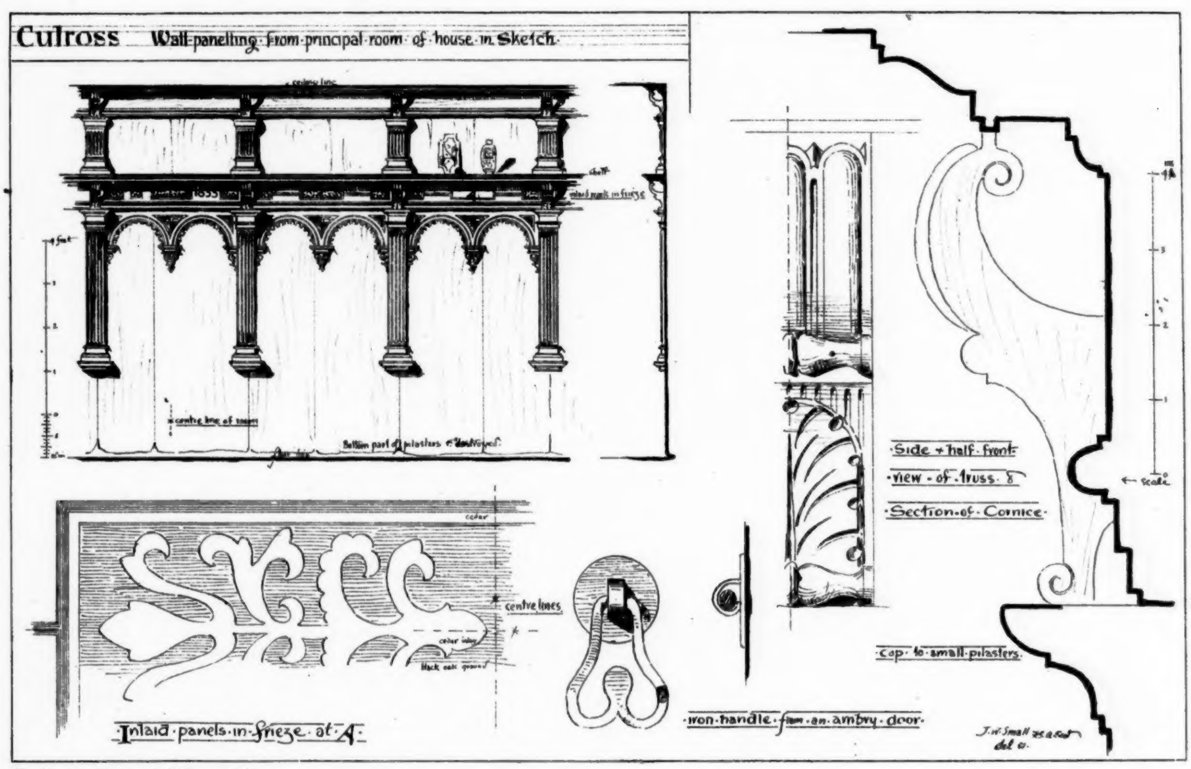
The expansion and contraction of solid metals from an increase or diminution of their temperature is much less in quantity than in the case of liquids, being scarcely perceptible for moderate degrees of temperature. In some metals the change which takes place is much greater than in others, and is always more in proportion at high than at low temperatures; and if we increase the density of a metal by hammering or rolling, we find that its rate of expansion is also increased. The linear expansion of a rod of zinc 100 feet long, if heated from 0° to 100°, is 3.576 inches; that of a rod of lead 100 feet long is 3.384 inches; that of a copper rod 200 feet long is 2.064 inches; while a bar of wrought-iron 100 feet long expands only 1.464 inches, but if drawn into wire a 100 feet will expand 1.728 inches, and a bar of cast-iron 100 feet long is increased by 1.356 inches; one of untempered steel by 1.296 inches; but a bar of tempered steel is increased by 1.488 inches. A rod of glass expands about half as much as one of copper. The cubical or volumetric expansion of solids is in all cases three times the linear expansion. The force of expansion being equal to that necessary to compress the body to its original dimensions, we are able to calculate the thrust which a bar of iron exerts when it is heated through 100° and find that it amounts to 15 tons in a bar one inch square, and therefore to a proportionally greater force in a larger mass. From this we see how necessary it is that a certain amount of play should be always given to iron-work when employed in large quantities in a building, especially where it is exposed to considerable variations of temperatures, as in roofs, bridges, railway structures, etc., otherwise the supports may easily be overturned by the enormous force developed in the expansion and contraction of the metal.

When a bar of cast-iron has been exposed continually for several days to a temperature above 900°, it will be found that when allowed to cool again it has not contracted to its former length, but that it has become permanently elongated, so that if its original length was 100 inches, it will now be found to have increased to about 101 inches.

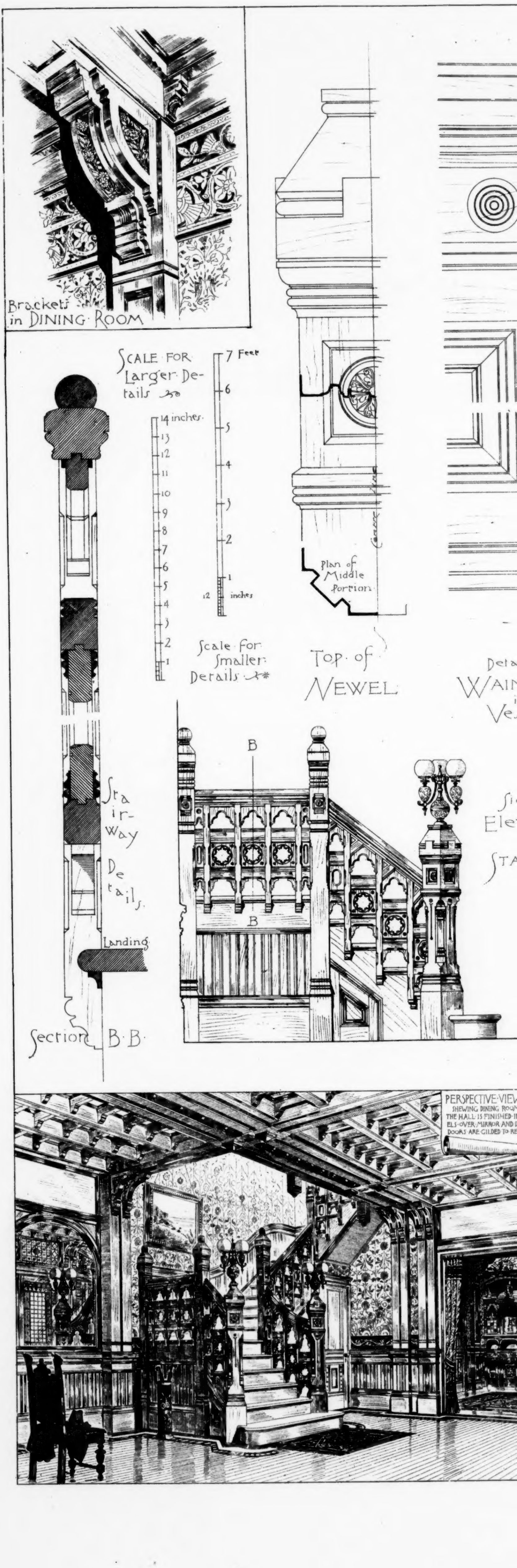
Water is not the only liquid that expands on becoming solid, for we find that molten iron has the same peculiarity, and this enables us to cast it in moulds of the most delicate patterns, as in solidifying it expands and fills up every part of the mould. If we put a ball of solid iron at any ordinary temperature into a mass of the molten metal, we shall find that at first it will sink to the bottom from its greater density, but that as it becomes heated it will get lighter in specific gravity, and will eventually rise and float on the surface as soon as it has reached its plastic state, or about red-heat, showing that the solid metal is of less density than the liquid iron. As soon, however, as the iron has solidified, it begins to contract with the lowering of its temperature, and this contraction has to be allowed for in making the patterns for castings. Thus, in passing from the

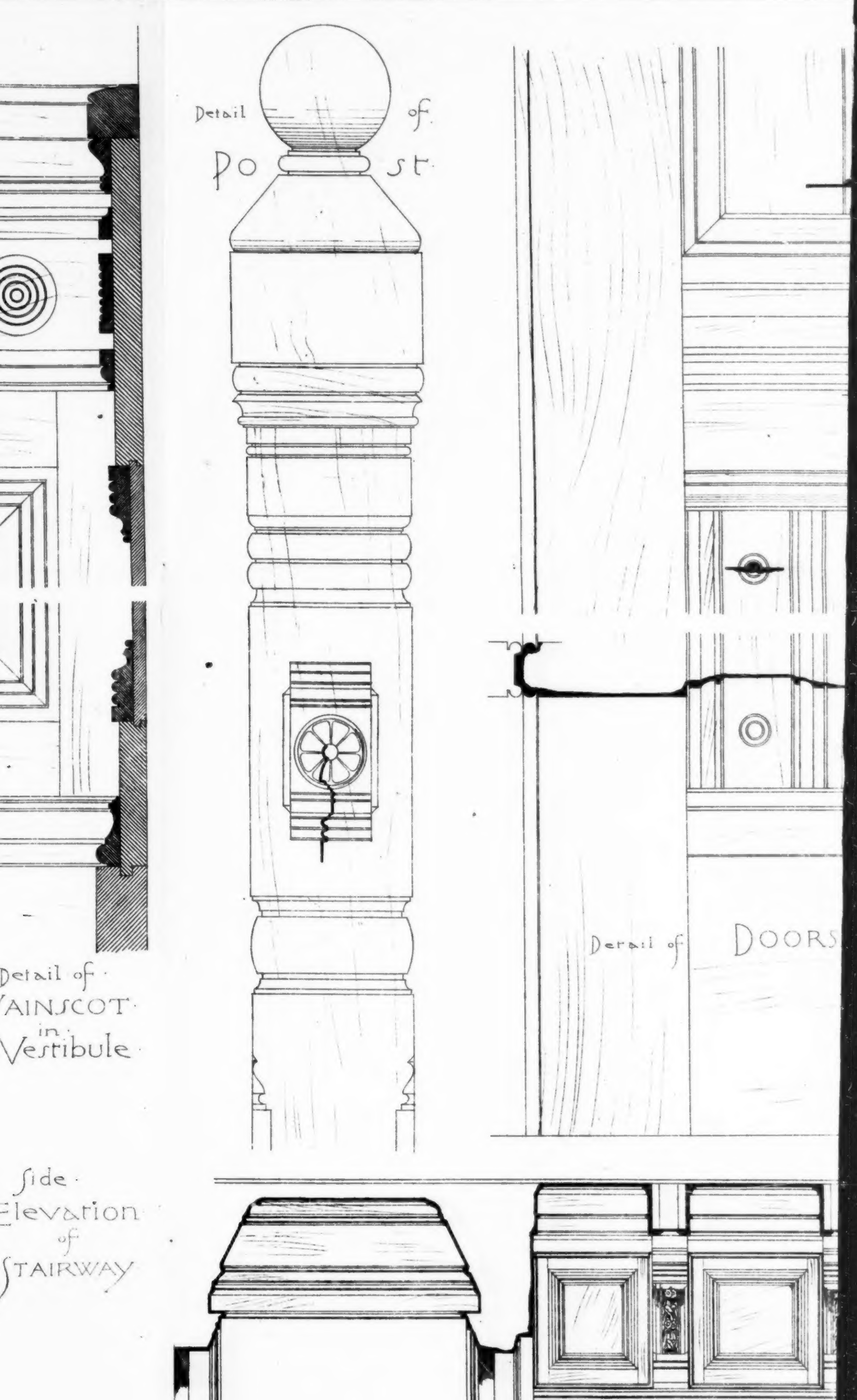

American · Architect "Competition" A hotel bedroom by Morpheus
Plan·of Room.
Vestibule
Corridor
Dressing Rm.
Closet
Curtain
Scale of Plan
Bedstead
Cap to Posts
Centre
Side Elevation
Elevation of Head End
Details of Bedstead End
Leg
View of Room.
Easy Chair
Detail of Easy Chair
Detail of Cornice
Section thro' Top Drawer &c.
Detail of Top
Section of Frame
Glass
Dressing Case with Details
End
Front
Section thro' End
Drawer
Washstand
Chair Leg
Front
Chair
Side
Detail of Top to Chair
Open Space for extra Water Vessel.
Shelf
Plan of Washstand
Scale of Feet
Details
Centre Table
Top



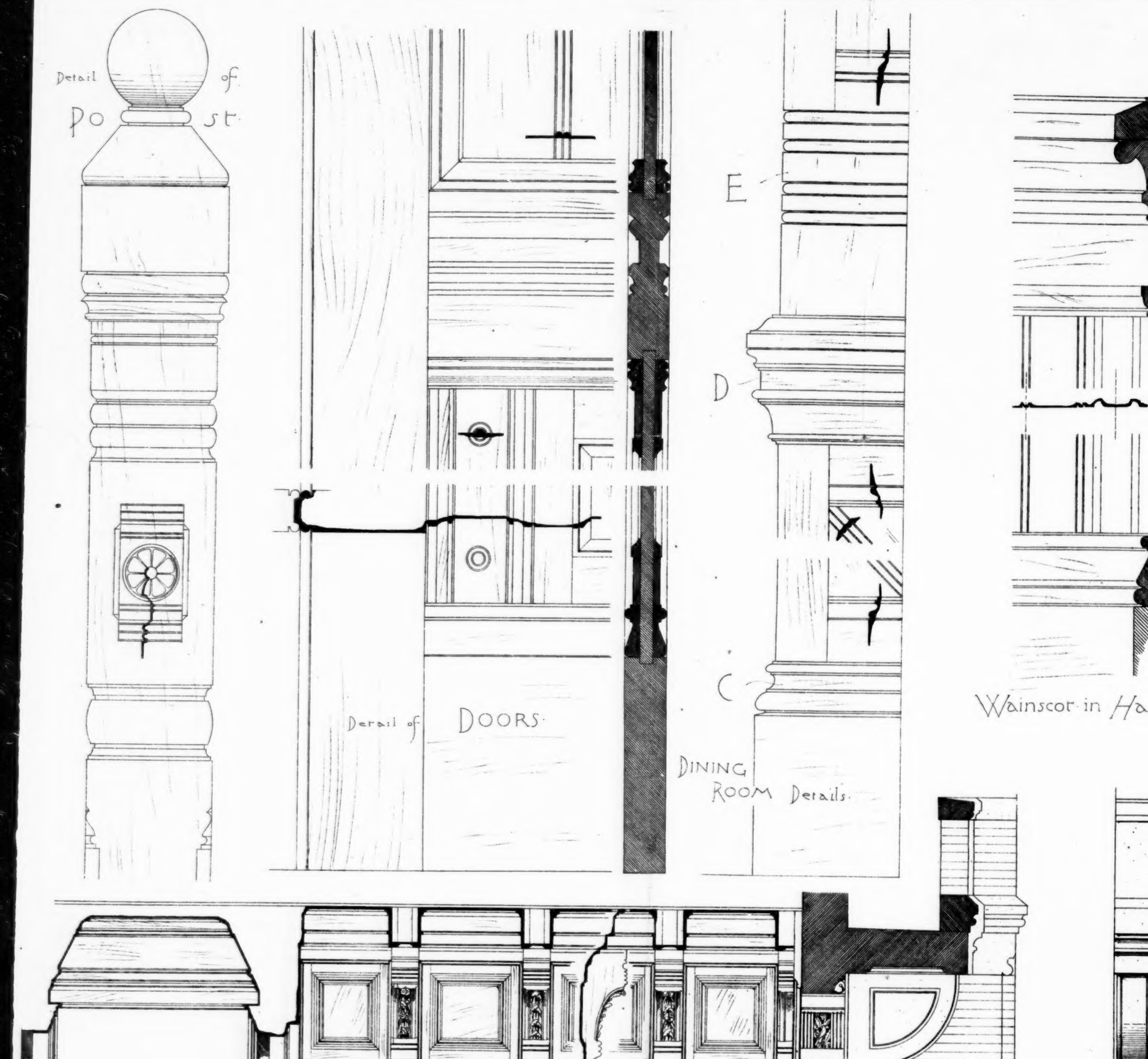


The Heliotype Printing Co 211 Tremont St. Boston.

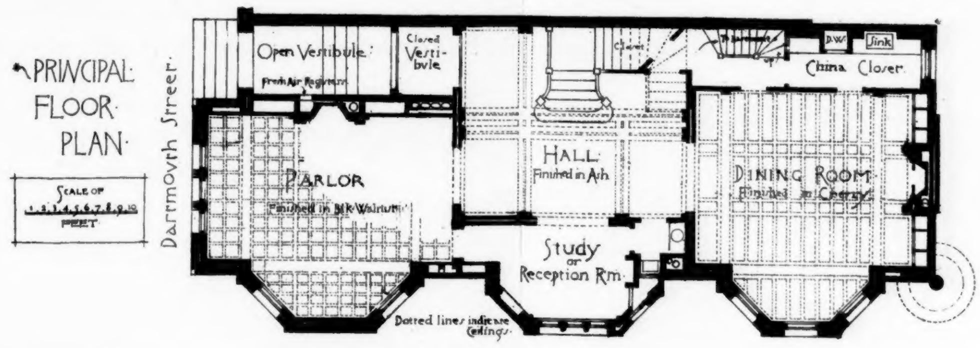

Brackets in DINING ROOM
SCALE FOR Larger Details
7 Feet
12 inches
14 inches
Scale for Smaller Details
Plan of Middle Portion
Top of NEWEL
B
B
Stair-Way Details
Landing
Section B·B



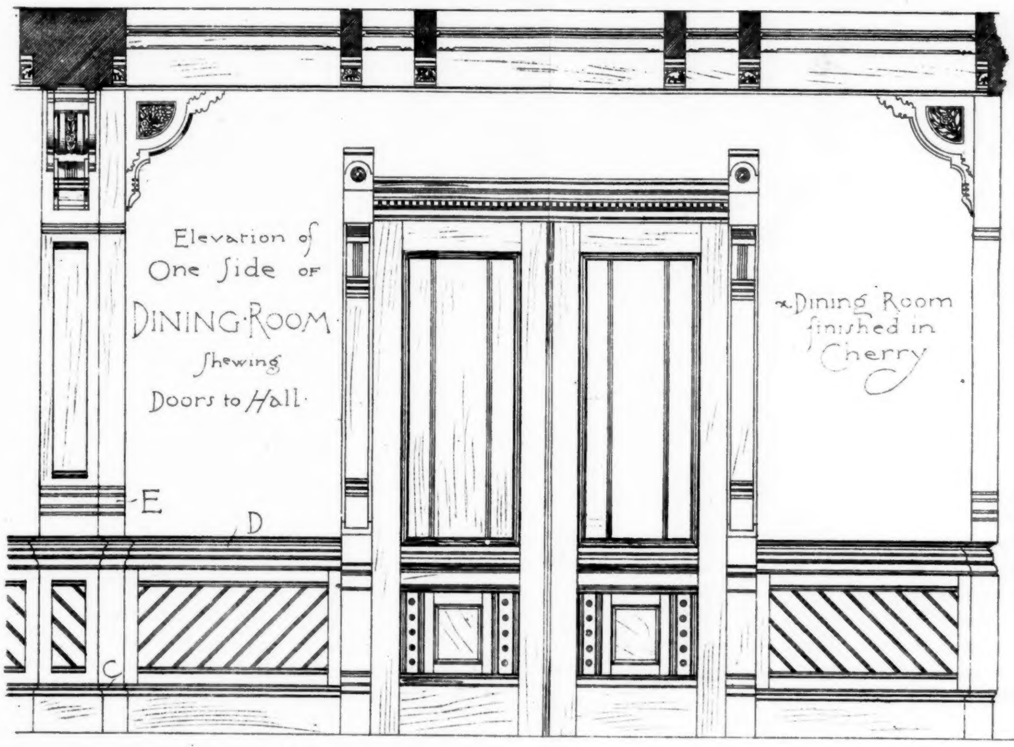
HOVSE CORNER OF DARTMOUTH AND NEWBURY STREETS BOSTON·
J·P·PUTNAM·ARCHITECT·BOSTON·

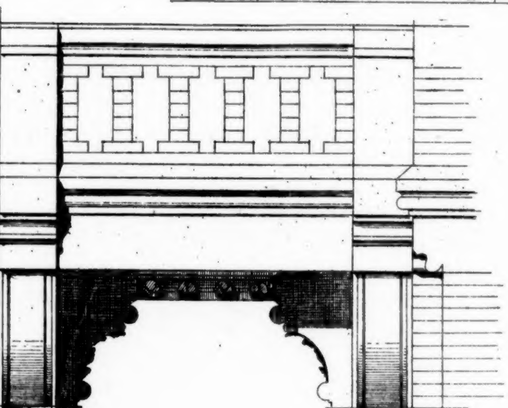


HOUSE CORNER OF DARTMOUTH AND NEWBURY STREETS BOSTON MASS
J.P. PUTNAM ARCHITECT BOSTON


PRINCIPAL FLOOR PLAN
Scale of 1 2 3 4 5 6 7 8 9 10 Feet
Darmouth Street
Open Vestibule
Fresh Air Register
Closed Vestibule
Closet
Hall
Finished in Ash
China Closet
D.W.
Sink
Parlor
Finished in Blk Walnut
Dining Room
Finished in Cherry
Study or Reception Rm.
Dotted lines indicate Ceilings


Hall


Elevation of One Side of Dining Room shewing Doors to Hall
Dining Room finished in Cherry
E
D
C


Front Elevation Entrance Doorway


Hall Ceiling in Ash


EXTERIOR VIEW

temperature of about 1,500°, at which it melts or solidifies from the molten state, to the average temperature of the air, it is found that iron contracts in length from one to two per cent, according to the quality of the metal.

From experiments which have been made in order to test the resistance to strains of iron at various temperatures, it appears that cast-iron beams attain their maximum strength at the temperature of melting ice, or 0° of the centigrade scale; and that if their temperature is reduced to —9° their strength is also reduced by about one-eighth. On the other hand, if a cast-iron beam is heated to 100°, or the temperature of boiling water, the strength is reduced by about one-eighth; but if heated to redness, or about 900°, it loses one-third of the strength it had at 0°. This result shows how little reliance is to be placed upon this metal as a material for fire-proof building, as in case of a fire occurring which would heat the metal above redness, the iron beams would give way under a load that they would easily support when cold.

Wrought-iron plates appear to attain their greatest tensile strength at the ordinary temperature, or about 16°, and to lose one-fortieth of their strength if the temperature is reduced to —18°, or the zero of the Fahrenheit scale. If heated to 100°, the strength of a wrought-iron plate is reduced by about one-ninth, and by one-fourth when red-heat is reached. Wrought-iron rods, however, would seem to be strongest at the temperature of 160°, losing one-fourth of their tensile strength when it is reduced to 16°, whilst at red-heat they lose above one-half of their strength. The resistance of some kinds of iron to strains is, however, affected in a much less degree by changes of temperature than other kinds, but in all the loss of strength is very considerable as they approach the temperature of red-heat, which may perhaps be partly accounted for by the density being reduced, since that is generally proportional to the cohesive force. When wrought-iron is heated to about 1,300°, or white-heat, it becomes so soft that two pieces of it can be welded together by hammering, and the welded joint is then as strong as the metal itself when it becomes cold.

Steel is a variety of iron which owes most of its valuable qualities to the action of heat. When a piece of soft steel is heated to redness, and then suddenly cooled by plunging it in cold water, it becomes very hard, and possesses great power of resistance to a crushing force, but is at the same time too brittle for ordinary use, as it will fracture at the slightest blow; but on being reheated to redness and allowed to cool slowly it regains its original softness and malleability. If the metal is now reheated to a temperature much below redness, and then cooled suddenly, it becomes softened to a degree inversely proportional to the temperature to which it has been raised, so that by carefully regulating this temperature we can give to steel any required amount of hardness or softness, this process being called "tempering" the steel. By hardening steel within certain limits of temperature we increase its tenacity, but if heated to bright redness the tenacity is reduced. The process of hardening steel has also the effect of diminishing its specific gravity or density, since the material becomes permanently expanded in its dimensions. Thus we find that while the specific gravity of unhardened steel is 7.9288, that of hardened steel at 11° is 7.6578. If, however, the metal is remelted, the specific gravity of the unhardened steel is 8.0923, which is reduced by hardening to 7.7647. The dilatation by increase of temperature is also greater in tempered than in untempered steel.

We are generally apt to regard iron and steel as good conductors of heat, which undoubtedly they are as compared with non-metallic substances, their conductivity being about twenty times that of hard sandstone; but as compared with other metals their conductivity is low, being only one-seventh that of copper and one-tenth that of silver. Their power of conducting heat is also less in proportion at high than at low temperatures.

Lead is a metal which has a very low fusing point as compared with iron, becoming liquid at 334°, and having a less density in the molten than in the solid condition, so that a piece of solid lead will not float in the molten metal, as happens in the case of iron. The expansion and contraction of lead by changes of temperature are considerable, for in being heated through 50° of temperature a sheet of lead ten feet long will expand one-sixth of an inch in length, and will contract by the same amount in cooling, the force developed in this change of length being equal to 1,000 pounds per square inch of section; hence arises the necessity of allowing it to have free play when laid as a covering of roofs, which are often exposed to quite as great a variation of temperature as that mentioned above.

The metal zinc has its character greatly modified by variations of temperature, an ingot of zinc being very brittle at ordinary temperatures, while if heated to 200° its brittleness is increased to such a degree that it may easily be reduced to powder. Between the temperatures of 100° and 150° it is, however, capable of being rolled into thin sheets or drawn out into fine wire. The degree of malleability which zinc possesses depends also on the temperature to which it has been raised when in the molten state, the metal being more malleable if cast at a temperature very little above 412°, its fusing point, than when it has been heated to a higher degree. The effect upon zinc of rolling it is to harden the metal, and in order to render sheet-zinc available for building purposes it becomes necessary to have it annealed at a low temperature, for if it is heated to a temperature at all near that at which it melts it will become brittle again. Zinc that has been cast at a temperature only just above the fusing point, and then cooled rapidly, is found to have a specific gravity of 7.178, but if cooled slowly it is less dense, and has a specific gravity of 7.145. A different result is, however, obtained if the metal has been heated to redness before casting, its specific gravity when cooled rapidly being in that case only 7.109, or if cooled slowly it is 7.12. Sheet-zinc expands and contracts by about the same amount as lead does for rise and fall of temperature; consequently the same precautions must be taken to allow it free play when used as a covering for roofs.

The effects produced by heat upon wood are very different from those produced upon metals, as might be expected from its being an organic substance. When newly-cut or unseasoned wood is exposed to a moderate amount of dry heat, its dimensions are found to contract, owing to the escape of some of the moisture which it contains in its natural state. At the same time, its power of resistance to strains is greatly increased after being kept for a considerable period in a dry and warm chamber. Thus, for example, we find that specimens of red deal have their crushing strength increased from 5,748 pounds to 6,586 pounds per square inch; of white deal from 6,780 pounds to 7,293 pounds; of Quebec oak from 4,230 pounds to 5,982 pounds; of English oak from 6,484 pounds to 10,058 pounds; of red pine from 5,395 pounds to 7,518 pounds; and of walnut from 6,063 pounds to 7,227 pounds. The process of boiling or steaming timber for the purpose of bending it does not appear to affect its strength in any material degree, provided it is only continued for a few hours, but if kept up for a long period the wood loses much of its resisting power. On the other hand, if timber is exposed for a long time to a high degree of dry heat, its strength is greatly diminished, and it becomes very brittle, a certain amount of moisture being essential to its strength.

When clay is burnt into bricks the effects produced by different degrees of heat are very conspicuous, the bricks which are nearest the fire being generally overburnt and clinkered so as to render them unfit for building purposes, whilst those most remote from the fire are often insufficiently burnt, and are called place-bricks, from their being too soft to be used for outside walls, as they crumble when exposed to weather, and do not possess sufficient strength to stand any great crushing load.

When rays of heat fall upon clear glass, one portion of them is reflected from its surface, another portion is absorbed by the material, and its temperature is thereby raised, while the greater part of the incident rays passes through the glass to the other side. The proportion of the transmitted rays depends somewhat on the thickness of the glass, since plate-glass $\frac{1}{4}$ inch thick transmits 60 per cent of the incident rays, while glass $\frac{1}{16}$ inch thick transmits 70 per cent of them. About 10 per cent of the incident rays are reflected from the surface of glass in the same manner and according to the same law as those of light are reflected, and consequently about 30 per cent are absorbed or dispersed by glass $\frac{1}{4}$ inch thick, and 20 per cent by glass $\frac{1}{16}$ inch thick. Although the expansion of glass when heated is very small in quantity, yet it is sufficient sometimes to produce fracture in large sheets if too tightly fitted into frames formed of unyielding material. Thus, a sheet of glass 10 feet long will expand $\frac{1}{10}$ inch in length if raised through 100° of temperature, so that if fixed firmly in iron frames, which also expand when heated, it follows that fracture must necessarily ensue, especially where the glass is very thick and will not readily bend. The low conducting power of glass also often causes the fracture of thick plates, for if they are heated to a considerable degree, and are then suddenly cooled on one side, the unequal shrinkage will produce a crack in the glass. The brittleness of glass can be much reduced by carefully annealing it, which is done by cooling it very slowly from a high temperature; plunging in boiling water or oil, and allowing it to cool gradually, adds much to the toughness of glass.

The absorbent power which materials possess for rays of heat differs widely in various substances, and depends a good deal on the nature of the surface exposed. If a surface is coated with lamp-black or with white lead the whole of the heat rays are absorbed, which causes the temperature of the body to rise rapidly, and the heat is then given off again by radiation, so that it is not advisable to use these materials on portions of a building much exposed to the sun's rays. Metallic surfaces, such as those of iron, zinc or lead, absorb only 13 per cent of the incident rays of heat, and consequently do not become very rapidly heated by exposure to the sun or any hot body. Bright zinc reflects 80 per cent of the incident rays, iron 75 per cent, and lead 56 per cent, the difference between these quantities of heat reflected and the amount absorbed being dispersed or reflected in an irregular manner. Dark-colored slates absorb much of the heat which falls upon them, which renders a room immediately under a slated roof very hot in summer. It is found that a coating of whitewash laid on the outside of the slates reduces very much their absorbent power, although a coating of white-lead paint would have, as we have noticed above, the opposite effect of increasing the absorption of heat.

In the construction of furnace chimneys it is of great importance to use such materials as are bad conductors of heat, so that the draught of the flue shall not be reduced by the lowering of the temperature through the escape of heat to the outside. A chimney built of stone will lose only one-twentieth of the heat that an iron flue would lose since stone is a bad conductor as compared with metal, and one built of brick, which has still less conductivity than stone, will lose less heat in proportion. A great loss of heat, however, is occasioned when newly-built chimneys of stone or brick are used before being thoroughly dried, from the quantity of moisture they contain, the evaporation of which absorbs a large quantity of heat, which becomes latent in converting it into vapor. If a material is used which is pervious to rain, there will always be a difficulty in keeping up the draught of the flue, owing to the same cause, which renders a double casing desirable in such structures.

EQUILIBRATION OF ARCHES.

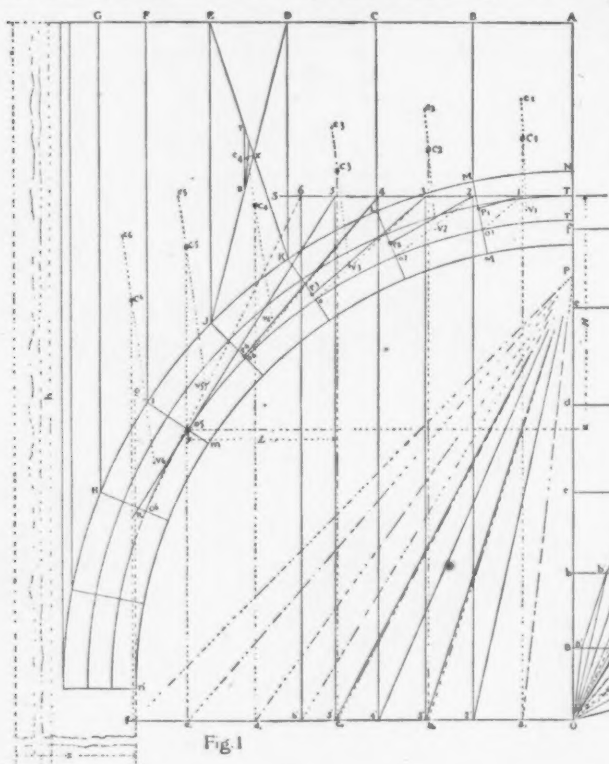
A METHOD OF DETERMINING THE LINE OF PRESSURE IN AN ARCH OF ANY FORM, LOADED IN ANY MANNER.

THE conditions of stability in an arch are, —

I. The curve of pressure in that portion of the arch which is above the joint of rupture must not pass outside of the middle third of the arch-ring.

II. The line of direction of the pressure at any joint must not make an angle of more than 30° with a perpendicular to the joint.

III. The mean pressure on any joint must not exceed one-twentieth of the ultimate resistance of the material to crushing.



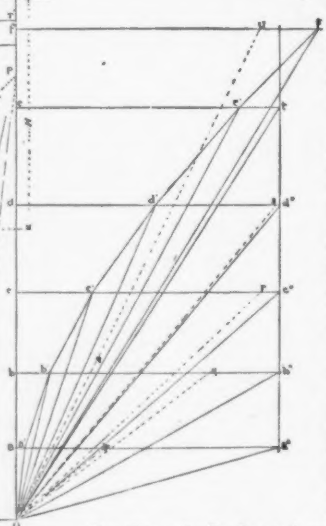


Fig.1

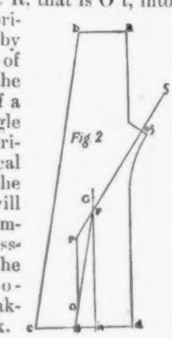
PROCESS.

Draw one-half of the arch, as in Fig. 1, and the wall above it, to as large a scale as practicable. Divide the arch-ring into three rings of equal depth, and into any convenient number of equal voussoirs. From the points M, L, etc., draw the verticals M B, L C, etc. Find the area of each of the loads, A B M N, etc., taking M N as a straight line, and multiply it by the number of pounds in a cubic foot of the material. (For convenience assume the arch and pier to be one foot thick.) Find the area of a voussoir, and multiply it by the number of pounds in a cubic foot. Find the centre of gravity of each of the loads as indicated in D E J K, thus: Draw the diagonals D J, E K; from J lay off Jz=Dx, and from E lay off Ey=Kx. From z draw a line to the middle point of x y, and from x to the middle point of z y; the intersection of these lines at c_4 will be the centre of gravity of the quadrilateral. In like manner find c_1, c_2, etc. Find the centre of gravity of each voussoir, v_1, v_2, etc., taking it as in the middle of the depth, on the radial line which divides the voussoir into two equal parts. Connect c_1 and v_1; c_2 and v_2; and so on. Find C_1, the common centre of gravity of the weight of the load concentrated at c_1 and that of the voussoir at v_1, as follows: Multiply the weight at v_1 by the distance c_1 v_1, and divide the product by the sum of the two weights; the quotient will be the distance c_1 C_1. In like manner find C_2, C_3, etc. From any point O on the vertical N O lay off, by any convenient scale (1000 pounds to an inch, or 2,000, or 5,000, or 10,000, according to the size of the arch), a distance O a to represent the weight at C_1, a b the weight at C_2, b c that at C_3, and so on; and from a, b, c, etc., draw horizontal lines indefinitely to the right. From C_1, C_2, etc., draw verticals, C_1 a_1, etc., to a horizontal passing through O. From any point P draw lines to a_1, b_1, c_1, etc. From O draw O a′ parallel to P a_1; from a′ draw a′ b′ parallel to P b_1; from b′ draw b′ c′ parallel to P c_1; and in like manner c′ d′, etc. Connect each of the points b′, c′, etc., with O. Draw P 2′ parallel to O b′, P 3′ to O c′, etc. The point P 2′ determines the vertical in which lies the common centre of gravity of the first and second weights, at C_1 and C_2; P 3′ of the first, second and third; and so on. Through T, at the upper edge of the middle third of the arch-ring, for ordinary semicircular, segmental or semi-elliptic arches, but at T′, the lower edge, for pointed and for light segmental arches, draw the horizontal T S. From 2′, 3′, etc., draw the verticals 1′ 1, 2′ 2, etc., to T S. From 1 draw 1o_1 to the point where the lower edge of the middle third intersects the joint M M′, the assumed edge of rotation for the first voussoir and its load; and draw 2 o_2, 3 o_3, etc. Draw O p parallel to 1 o_1, O q to 2 o_2, O r to 3 o_3, O s to 4 o_4, O t to 5 o_5, O u to 6 o_6. The line O t which cuts off the greatest ordinate on the horizontals from a, b, c, etc., e t in this case, determines the horizontal thrust at the crown, which, in pounds, is e t measured by the scale of O a, a b, etc.; and its parallel 5 o_5, at its point of tangency with the lower edge of the middle third, determines the position of the joint of rupture I m′. The accuracy of the work thus far may now be tested. The thrust at the crown should be equal to the sum of all the weights at C_1, C_2, etc., multiplied by the distance *L*, and divided by the distance *H*. The line O t, measured by the scale of O a, etc., gives the pressure at o_5, in pounds.

How many voussoirs and loads it will be necessary to take in order to find the maximum ordinate cannot be decided in advance, but the part of the arch-ring above the joint of rupture will rarely be more than three-fourths of the whole.

To a vertical through t draw O a″, O b″, O c″, etc. Draw 1 p_1, parallel to O a″, 2 p_2 to O b″, 3 p_3 to O c″, etc. The points T, p_1, p_2, p_3, p_4, o_5, are in the curve of pressure. If p_1, p_2, p_3, p_4, are all within the middle third the arch is safe, provided the other conditions of stability are observed. If the curve runs *below* the middle third, the arch is too heavily loaded over the crown, or too lightly over the haunches; if *above*, these conditions are reversed, and the arch is in danger of falling by rising at the crown.

To determine the necessary width of a rectangular pier to carry the arch: Protract 5 o_5 to R. Decompose the pressure exerted at R, that is O t, into its vertical and horizontal components, by the parallelogram of forces, making O t the hypothenuse of a right-angled triangle whose base is horizontal. The vertical side, measured by the scale of weights, will give the vertical component of the pressure and the base the horizontal component. The pier is taken as one foot thick.



Let H = the horizontal component.

Let V = the vertical component.

Let h = the height of the pier, known or assumed.

Let a = R X, the level arm of the horizontal component.

Let w = the weight in pounds of a cubic foot of the pier.

Let x = the required width of pier for bare equilibrium. The moment of H is then balanced by the moment of V plus the moment of the pier. The moment of H is H a. Y being the edge of rotation of the pier, the moment of V is V x, and the moment of the pier is its weight w h x multiplied by $\frac{x}{2}$. We have then the equation,

$$H\,a = V\,x + \frac{w\,h\,x^2}{2}, \text{ whence } x = \frac{\sqrt{2\,H\,a\,h\,w + V^2} - V}{h\,w}.$$

For stability take $\frac{4}{3}$x, or more. No account is here taken of the triangle o′ m′ n′, nor of the fact that the specific gravity of that part of the arch which is included in the pier (all below the joint of rupture) may be greater than that of the pier itself; but these are unimportant, and add slightly to stability.

When the pier is not rectangular, the outer face, or the load line, or both, being sloped, the formula for determining the width is very complicated, too much so for common use. When only the load line slopes it will answer to take h in the above formula equal to a mean between the inner and outer lines of height. The error in so doing is in favor of stability. When the outer face of the pier slopes, proceed as in Fig. 2. Assume the width at top a b and the base line c d. Find G, the centre of gravity of the pier, as above directed for a quadrilateral, and through it draw a vertical G h. Protract the line of pressure 5 o_5 across the pier, and from F, where it intersects the vertical, lay off the distance F p representing, by scale, the pressure. From p draw p o, vertical, representing the weight of the pier, taken as one foot thick. Draw F o, and protract it to the base at s. If c s is not less than one-half of c h, the structure is sufficiently stable. If it is less make another trial with greater width of base. The same method may be used with a rectangular pier, and in that case c s may be not less than one-third of c h.

THE EXHIBITION OF BUILDING MATERIALS.

WE desire to call attention to a suggestion in another column made by Mr. Atkinson as to the desirability of exhibiting at the approaching exhibition of building materials any kind of incombustible varnish that is made. It is extremely desirable to make this exhibition as comprehensive and instructive as possible, and any one who will take the trouble to follow Mr. Atkinson's example, and send to us the names and addresses of patentees or manufacturers of building appliances which should find a place in such an exhibition, may rest assured that his suggestion will be found acceptable, and that an attempt will be made to secure a proper exhibit of the article in question.

Architects can lend a much needed assistance in several ways: by forwarding to us such manufacturers' circulars as they have no further use for; by sending to us such duplicate specimens of materials and apparatus as now serve only to encumber their offices; and by personally recommending to manufacturers whose goods they have used and have found satisfactory to take advantage of the opportunity that is now offered.

BUILDING A HOUSE ON A SAND-HILL.[1]

As I am not aware that it has ever before been attempted in the United States to build a house on the very top of a lofty sand-hill, exposed to all winds and weather, while simply depending upon, or rather by simply making the loose sand the agent to keep it firmly secured in its seat, I think a few words upon the construction of a signal station, which I have just finished for the Maritime Exchange of this city, on top of the highest sand-hill at Cape Henlopen, may be of interest to some.

The signal station mentioned will serve to report the arrival at and departure from the Breakwater of all passing vessels, to the Philadelphia Maritime Exchange, by means of the Western Union Telegraph lines which connect it with this city.

In the first place, it was necessary that the observer stationed in the building should have a clear and unobstructed view of the seaward horizon from south to north, that is, seaward of the coast line. To obtain this it was necessary to erect the building on top of a hill, which rises some 80 feet above the level of the sea. But the building thus necessarily becomes exposed to every gale that sweeps that part of our coast, while it is absolutely required that it shall stand firmly planted in such a way that even a hurricane shall not shake it or make it tremble, as that would affect the sight of the telescope in the observatory.

The usual mode of securing is by building a foundation of screw piles or of heavy timbers sunk into the sand; the latter mode, however, has this disadvantage, that if the wind shifts the sand away from around the foundation, it becomes undermined and its effect is thus destroyed.

In order to be independent of all this, I designed what I consider a cheap and, at the same time, an effective anchorage for the building in the following manner. The building is of wood entirely; it has a cellar, above which are two rooms, one above the other, and the whole surmounted by the observatory proper. First, the ground-sill is a square of 20 feet, made of yellow-pine sticks, mortised together and pinned with stout trunnels. The sill of the observatory is made likewise of heavy timbers, 12 feet long. The two sills are joined together by four stout yellow-pine corner-posts, which in turn are mortised into both sills. The posts are 26 feet in length. Five feet above the lower sill is the sill which supports the floor of the first room. ten feet above this is the sill which supports the upper room. Both these sills again are mortised into the corner-posts. This structure is sheathed outside with German siding, inside with rough boards covered with felt, and again by tongued and grooved yellow-pine boards. The observatory proper, octagon in shape, is securely mortised into the top sill and is covered with a corrugated-iron roof, conical in shape. The cellar is floored with 3-inch wood, and boarded all around on the inside of the posts.

I first dug a pit in the sand, about 6 feet deep and fully 20 feet wide on the bottom. I then laid the ground or cellar sill on this bottom, and built the structure; thus the whole depth of the cellar is sunk below the top of the hill, or the level of the sand. I then filled the cellar up solid with sand, and packed it solid all around the outside also; consequently the building is anchored in its place by the load in the cellar, some 100 tons in weight.

I carried three heavy joists (part of the joists which carry the first floor) through on one side of the building, and on these the kitchen was built, so that this is also independent of the position of the sand under it. Since the construction of the station we have had some very severe blows, yet there is no more tremble in the building than if built of stone on a rock.

A few feet from the building stands a signal post or mast 100 feet high, which carries a 5-foot ball of rattan covered with canvas; the ball is made to slide on the mast, and is used to answer signals from vessels by raising and dropping it. As it would, in my opinion, be a rather dangerous thing to simply place the mast in the sand, — no matter how deep, — I sank a well into the sand-hill.

This well is made of pine, 20 feet deep and 8 feet square. The mast is placed in the centre of the well and is braced, from the corners of the pine box, by some 20 stout braces, and the well afterwards filled and tightly packed with sand inside and outside, so that, like the house, to blow it over would necessitate moving of a tremendous weight of sand with it.

[1] A paper by Mr. J. J. de Kinder read before the Engineers' Club of Philadelphia.

SOUTHERN HARD-PINE AND SPRUCE TIMBER.

IF a dealer has an article in which he has real faith the best way to introduce it into notice is to advertise it, and according as the ingenuity of an advertiser is well or ill directed, so is the success of his efforts and the ratio of his sales. There are no limits to the ingenuity of the advertiser, but it seems to us that Messrs. Stetson, Moseley & Co. discovered an admirable way of putting their Southern hard-pine lumber on the market when they thought of issuing the useful little tables[2] before us, tables which, dealing with the merchantable sizes of lumber, and prepared with the special object of making them useful to architects and builders, should form a welcome addition to the working library of any architect.

Based on observations made by Captain T. J. Rodman, U. S. A., while stationed at Watertown Arsenal, the results here tabulated have been computed by Messrs. Crafts & Forbes, civil engineers of Boston, so that all the facts necessary to the authentication of the results are indicated. It would have added to the value of these tables if some statement had been presented of the manner in which Captain Rodman conducted his experiments, and also as to how many of the results tabulated are the record of actual experiments and how many are merely deduced from such experiments by calculation. In any such tables as these, it is extremely valuable to know at what points the theoretical deductions from the leading experiments are corroborated and endorsed by other actual experiments. However, conciseness and serviceableness were prime considerations with the compilers of this little work, and so long as we know where to find them in case errors are discovered, or explanations of their methods are desired, it is less important to know now just what these methods were. It is enough to know that the work has been done for architects in such a way as will be very serviceable to them, and which they will highly appreciate.

The Boston Manufacturers' Mutual Fire Insurance Company, finding, we believe, that there was no satisfactory record of the strength of yellow-pine timbers, particularly when used as posts, has just begun to carry out a series of tests at the Watertown Arsenal under the supervision of Colonel Laidley, and as all that it undertakes is executed with satisfactory thoroughness, it will be interesting to compare the results it arrives at with those which are recorded in this little book of a dozen pages. We think it not impossible that had these tables been published sooner, this second set of experiments would never have been carried out, for we find that the last table in the book is devoted to the strength of posts, and we here learn that the crushing load of a Southern-pine post, six inches square, and fourteen feet high, is 69,632 pounds, while columns of oak and spruce of the same dimensions crush under a weight of 60,928 and 56,576 pounds respectively. We trust, however, that the second set of experiments will be carried out and the results tabulated in a similarly intelligible and useful form as the first have been.

Another serviceable little book[3] which contains much information for builders and architects has reached us, and proves to have more in it than it appeared to have at first sight.

Besides the interest table usually found in such handbooks, tables explaining the mysteries of board measure, plank measure and scantling measure are all duly tabulated, running in the case of boards from 12″ x 6″ up to 31′ x 2′ 6″, in the case of scantling from 12″ x 2″ x 2″, to 31′ x 11″ x 12″, and in the case of planks from 12″ x 1¾″ x 7″ to 31″ x 4″ x 24″, all of which tables may prove useful in preparing estimates when taken in connection with another set of tables, where the cost of lumber is given for amounts rising from one foot to 4,000 feet, at prices increasing from $8 per thousand to $125.

Other tables of value are those which give the capacity of cisterns and the contents of granaries, and a few other miscellaneous tables, amongst which one always expects to find some amusing if not very valuable information, but the compiler of these tables was not writing a jest book, and we must content ourselves with a smile at the statement that there are in one bushel of Timothy grass seed 41,823,360 seeds.

PLASTERING ON BRICKWORK.

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

THE answer to "Justice" in No. 284 of your journal contains some statements regarding hollow walls which, though popular and generally received, are nevertheless erroneous, if proper care and necessary skill are used in their construction.

The hollow space should be one and one-half inches wide, with

[2] *Tables Showing the Comparative Strength of Timber* of the various Kinds used for Building Purposes, with other Useful Information for Architects and Builders. Presented by Stetson, Moseley & Co. Boston: 1881.

[3] Handbook of Useful Tables for the Lumberman, Farmer and Mechanic: Containing Tables of Interest at Six Per Cent, Wages per Month and Week, Board or Rent per Week, Board, Scantling and Plank Measure, Cubic Contents of square and round Timber, Cubic Contents of round Timber when squared, Logs reduced to Inch Board Measure, Standard Contents of Logs, Wood Measure in Load and Pile, Cost of Wood, Cost of Lumber, Weight of Grains per Bushel, Contents of Granaries, Bins, etc., Capacity of Cisterns, Weight of seasoned Lumber per 1000 Feet, Weights of Solids per Cubic Foot, Liquors per Gallon, Wood per Cord, Length of Nails and Number in a Pound, and other valuable Tables, besides miscellaneous and useful Information, etc. Ithaca, N. Y.: Finch & Apgar, 1881.

headers every third course, alternating four headers and two stretchers, so that the space or hollow shall be left *half* open and continuous, and so arranged that the headers of each succeeding course shall come *over* the stretcher or opening in the heading course next below, in order that the droppings of mortar shall not accumulate largely on any *one* course, and thus render the wall practically solid for a considerable portion of its height. For work done in the ordinary manner with bricks of ordinary porosity no special provision is necessary for ventilating the space enclosed, as the unplastered portions of wall between joists, and the openings under wall-plate, will give the circulation necessary to remove transmitted or condensed moisture. By using the hollow wall, the furring strips, which practically diminish its thickness by exactly the amount of their width, are avoided. The moisture is arrested in the hollow space and does not come in contact with and hasten the decay of furring timber, etc., rendering apartments *odorously* mouldy and damp, when not thoroughly and frequently aired. Superiority of plastering on brickwork and the saving of the cost of lathing and furring are items not to be overlooked. As to the relative strength of solid and hollow construction, I am aware there may be a diversity of opinion; I have no doubt, however, that the hollow wall with its somewhat defective bond, but increased breadth of base, is *more* rigid than the same amount of material built *solidly* and having its thickness reduced by the furring strips built in. During the past fourteen years my experience has been quite extensive with this class of work: I have yet to find an instance where the walls are damp or "sweat" from condensed or transmitted moisture. RECTUS.

[WE are glad to hear *Rectus's* experience in the building of hollow walls, but think the climate in which he lives may be of some assistance in keeping such masonry as he describes dry. On the Atlantic coast, with the bricks ordinarily obtainable there, nearly every bonding brick in such a wall would before many seasons be indicated on the surface of the interior plastering by a spot discolored by the penetration of moisture, unless rapid ventilation of the air-space, cement joints, or exterior painting should have succeeded in checking the transmission of water. — EDS. AMERICAN ARCHITECT.]

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

Dear Sirs, — I am desired to ask what is the latest device for preventing spots on the inside of a double wall when the plastering is laid on without furring; whether saturating bonding brick with coal tar has proved effectual.

Also whether there is any cheap way of filling in between studs in a common partition-wall with rubble or concrete to make them solid.

Yours truly, X X X.

[WE have not heard of anything more recent in hollow wall construction than the ordinary iron ties. Tarring the bonding brick has been tried, but has not, we believe, proved very satisfactory. Probably too large a surface has been left on the top, along which water may creep, and the tarring is an expensive and disagreeable job. The bonding bricks are sometimes surrounded by clear cement, and if the hardest specimens are selected, this ought to be as effectual as the other mode. We have heard of tarring the inner surface of the outer wall, which may sometimes be useful. Metal ties are much more likely to give satisfaction than those of masonry, and if set in the *vertical* joints, as can safely be done in walls not too high, our experience is that no transmission of moisture need be feared. Around window jambs, which are necessarily solid, there will always be dampness after heavy rains, unless, perhaps, clear cement is used instead of mortar.

For filling in between studs, soft bricks, put in dry, form much the best and cheapest material. The refuse of the kilns can be used, and no mortar is necessary.—EDS. AMERICAN ARCHITECT.]

WHY WE REJECT DESIGNS.

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

Gentlemen, — Yours of yesterday is at hand. I would say that from the fact that you have solicitated contributions for your paper, and from the fact that you have already published one of my designs, I supposed you were ready to receive drawings from subscribers, at least, if not from others. I have taken your journal *from the start*, and as I had purposed sending you at a later date some of my more recent designs, I should consider it very kind and courteous if you would give me some idea of the cause for rejecting my design. If you consider it inferior and unworthy of publication, I am satisfied with its return, but if the *American Architect* receives and publishes the designs of only certain architects, that is another matter.

Respectfully yours, X.

[THE preceding letter is so admirable a sample of the many letters of similar character that we have received, and probably will receive, that we think it best to give it a public answer. Our correspondent apparently adopts the common mistaken belief that the payment of his subscription constitutes him in some degree a co-proprietor with the publishers, or at least a co-editor with ourselves. It is hardly necessary to say that the fact that a subscriber has sent us the price of subscription for several years entitles him, *ipso facto*, to no different treatment from that which we extend to the newest subscriber on our list. The excessively unpleasant and discourteous innuendo in the last sentence is perhaps less excusable than it sometimes is,— for we regret to say that it is an insinuation only too frequently made against us,— for with unaffected simplicity our complainant admits that it is gratuitous by reminding us that we have already published one of his drawings. The utter fallacy of the accusation can be detected by an inspection of the names of those whose designs have been published, or still more easily by a similar examination of the names of authors of rejected drawings. After either examination one would be puzzled to determine who the "certain architects" are in whose favor this journal is maintained. It must be admitted, we believe, that editors must edit, and it is as much the function of an editor of an illustrated journal to reject drawings as to refuse manuscripts, though unfortunately it is a much more disagreeable duty to perform. For a year or two we undertook to state our reasons for declining to publish a drawing, but we found that not only it took much time to explain them, but that we were expected to join issue on the matter, and that answer, reply and rejoinder were to follow one another in due sequence. At length we abandoned this course and adopted a printed form of refusal, and disregarding the advice of more experienced editors, who recommended us to use the most concise and uncompromising wording, we couched it in as courteous words as we could devise. In this way we have been relieved from the necessity of explaining our unwillingness to publish a given design, but we have not been able to ward off letters which impute to us unworthy motives, and consequently we suppose that as time goes on and new subscribers are attracted to our journal, and new complainants are made, we may be compelled by such letters as the one above to state in public that it is impossible for us to explain the motives which control our actions, and to reiterate the assertion that so far as it comes within the limits of possibility this journal is edited with strict impartiality, and that it is not conducted in the interests of the American Institute of Architects, or of any clique or body of the profession. — EDS. AMERICAN ARCHITECT.]

A BOOK ON THE ARCH.

1267 BROADWAY, NEW YORK, June 20, 1881.

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

Dear Sirs, — Will you kindly favor me in your next number of *American Architect* with the name of a good and simple treatise on the Arch, one that will enable me to calculate the size of abutments, knowing the weight that is to be carried.

I have "Cain on Arches," but it does not seem to give me what I want. Truly yours, SUBSCRIBER.

[ALLAN'S "Theory of Arches" published by D. Van Nostrand, New York, price 50 cents, is a useful and intelligible little book.—EDS. AMERICAN ARCHITECT.]

INCOMBUSTIBLE VARNISH.

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

Dear Sirs, — I have lately observed several buildings in process of construction on the *mill plan*, so called, with solid beams and plank floors, and in all respects admirable save one; in some cases the wood is planed and varnished with the ordinary combustible varnishes.

This is a dangerous practice that might well be avoided. A fire will spread over the surface of the varnished wood, when varnished in the ordinary manner, about as rapidly as it will spread over the surface of open cotton; and if it does no harm except to the surface, yet the fault ought to be avoided.

There are several hard fillings said to be composed mainly of silicate of soda, of which I believe the Wheeler patent wood-filler is one, that might be used if they are cheap enough.

We are not well informed on this matter, as the interior of factories is usually whitewashed.

I suggest that in the collection of building materials now being gathered for the Mechanics' Association Exhibition, a call be made for specimens of wood, finished with *incombustible* varnish.

Yours very truly, EDW. ATKINSON.

PUBLISHING THE COST OF BUILDINGS.

OREGON, MO., June 23, 1881.

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

Gentlemen, — I am one of the many *non-professional* readers of your paper who take great interest in the engravings of dwellings which appear frequently; but my enjoyment is greatly marred by the *frequent* omission of *plans* and the *constant* omission of a statement of *probable cost*.

Could not these omissions be filled in future?

Truly yours, D.

[THE complaint which is voiced by our correspondent is one which has often been made, and we have done what we could to persuade architects to remove the grounds for the first head by furnishing in every instance the plans of the building which they send for publication, but the belief that the chief end of the *American Architect* is to publish "pictures," to the exclusion of architectural drawings pure and simple, seems to be very deeply rooted. As to the other head of the complaint we fear nothing can be done, for an architect has no more right to divulge the cost of the building he has designed for a client than a trustee has to state the amount of a property which has been placed in his charge. Now and then an architect may obtain the consent of his client to a statement of cost, but it is easy to understand that such cases must be rare, and we would be the last to ask our contributors to place themselves on a level with the ordinary newspaper reporter by lifting in any further degree the veil which already so scantily conceals the private life of an American citizen.—EDS. AMERICAN ARCHITECT.]

NOTES AND CLIPPINGS.

ELM-WOOD. — The use of elm-wood for various purposes is claiming the attention of manufacturers. The elm marketed is known as the "gray elm." Elm of any kind is rightly designated when it is called "tough," and tough it is after the manner of tough leather. Its grain is not straight and easily separated like oak, or some other woods, but is interwoven, gnarled, knotty and tough, as any one may learn who attempts to cut it. The elm in use is the water elm found in high places. Until lately it was let alone and considered useless, but any farmer where elms grow knows the value of elm. When a new axe-handle is wanted, he does not buy the checky and cross-grained helve manufactured to wear out speedily, but makes one by his own handiwork from an elm limb. Such a helve will outlast a dozen of the machinery-cut kind. For all kinds of farming implements, elm is particularly desirable, as well as for wheel stock and any contrivance that requires strength. One firm is said to be supplied with a half-million feet of elm. The wood is coming into general use and is a valuable addition to the hard-grained woods. — *The Northwestern Lumberman.*

PAYING FOR CUT-STONE ESTIMATES IN CINCINNATI. — We are told that it is understood and generally conceded that the freestone dealers are only waiting to get a quorum at their meeting, in order to rescind so much of their late rules as refers to making charges for bidding on work. The resolutions were really passed under a mistake, and create a great deal of dissatisfaction among owners and architects.

NEW METHOD OF MAKING STEEL. — A Frenchman has devised, it is said, a method of converting iron into steel and at the same time producing illuminating gas. The iron is placed in a retort with charcoal or coke in layers, and is heated to 1,650 degrees Fahrenheit. Fatty matters are then injected, and as soon as decomposition has taken place, a jet of dry steam is passed over the incandescent mass. The iron is thus changed into steel, while carburetted hydrogen is given off from the retort.

A NEW DERIVATION OF "JERRY BUILDING."— An ingenious person has just hit upon a new and original derivation for the term "jerry," as applied to "jerry buildings," the work of dishonest or impecunious individuals engaged in the erection of house property. The derivation is so obvious that it seems a wonder nobody ever hit upon it before. This amazing philologist reminds us that "Joshua, the son of Nun, walked round Jericho in the old time and caused trumpets to be blown, whereupon the walls fell down with such facility that the builders must have been greatly blamed," and so their work became proverbial. A "Jericho builder," therefore, got to be a byword of reproach, and in the progress of ages the phrase has easily and naturally been corrupted into our modern term, a "jerry builder."

THE ESCURIAL FIRE. — In a book recently published, M. Charles Graux tells a striking story of the great fire at the Escurial in 1671, to which so many literary losses may be traced. The library itself was really not in danger from the flames, but the librarians in a panic first threw a great many books out of the window, and then removed the rest to a vaulted and thickly-walled room in another part of the building. But Spanish pride along with the MSS. had rescued the Turkish flag captured at Lepanto, and, by a strange accident, the Crescent at last avenged itself on the Cross. As the standard hung against a pillar beside the books, a spark from the blazing rooms outside fell upon it. It flamed up, fell upon the parchments lying heaped round it, and in a few minutes, before what had happened was even discovered, priceless MSS. had been destroyed. Their charred fragments were for the most part swept away into final oblivion, but some of the blackened leaves, says M. Graux, still survive to tempt the expert.

THE WILLOW. — Anybody who has the patience to wait five-and-twenty years for a large return upon a small expenditure should plant the willow tree. The demand for this wood during the last few years has been extraordinary, and the London dealers now readily wait upon any estate agent who has two or three fairly-grown willows for disposal. An average price for a good tree with plenty of top is £10. The wood is used for a variety of purposes. Boles just cut down, and free from disease and stain, are made into carriage bodies. Cricket-bats worthy of the name and the game are made of no other wood. It is the material also of many articles of modern furniture. The inferior parts of the tree serve for toys, for cotton or silk reels, or for conversion into charcoal. For many of the purposes we have named, the wood is first placed in scalding water, when it may be twisted, kneaded, cut, or stamped out, just like a piece of boiled cheese. Properly, of course, the willow should be grown upon the margin of a ditch or brook. It will grow more slowly and less perfectly in very moist and heavy soil. It should be planted in the spring or autumn. Those who want as rapid a development as the tree is capable of should not plant little sprigs, but a goodly-sized pollard lop, say from seven to nine feet long, and as thick as a man's wrist. If such a lop as this be placed three feet in the soil, failure is next to impossible. — *Land.*

SNOW-BALLING A FIRE OUT. — One morning in January, 1826, says a Montreal paper, after a heavy fall of damp snow the day before, a fire broke out in a large wooden warehouse, in which were stored six hundred barrels of pork and several hundred barrels of flour. It evidently caught near the top, for in a few minutes the roof of the building, which was of great length, was almost wreathed in smoke and flames, while the walls remained intact. A large crowd of men and boys rapidly collected, but the engine for some reason not arriving, and the river, the only source of water-supply, being covered with thick ice, and above all, the crowd being without a leader and utterly confused, nothing of importance was done to stop the fire, and the building seemed doomed to complete destruction. Just as the idea had settled into a conviction in the minds of those present, Henry Corse came rushing over to the scene from his factory, shouting at the top of his voice, "What are you thinking of, men? Why don't you snow-ball that fire out?" and, suiting the action to the word, he caught up a handful of the damp snow and flung it upward. The crowd caught the idea on the instant; all they wanted was a leader, and making a solid rush forward, they caught up the snow at their feet, and a moment later half a thousand snow-balls were mounting fireward and falling with a hiss upon the blazing timbers. Never was just such a sight seen before; the immense crowd surrounded and stormed the fire-fiend with a will, cheering and shouting in their excitement; the snow missiles flew upward thicker than hail falls in December. The great snow-ball fight of Napoleon and his fellows at Brienne school was nothing in comparison to it. Almost after the first half-dozen volleys the fire seemed to pause as if astonished at the novel mode of attack; before it could recover, another and another storm of balls fell upon it, until beaten and battered down at one point and flaming out at another, assailed with a moving wall of icy missiles wherever it burst out with renewed violence, in an hour's time it was completely baffled and under control, and in another hour entirely subdued. The only loss to the building was its roof, badly burned, while the stores of pork and flour inside were comparatively undamaged. — *Fireman's Journal.*

THE CORINTHIAN CANAL. — The London *Times* says: "French enterprise promises to undertake the accomplishment of a third great engineering feat in cutting a canal through the Isthmus of Corinth, which, both in ancient and modern times, has formed an obstacle in the way of commerce between the Adriatic and the Ægean. Our readers learned from our Paris correspondence yesterday that General Turr, a well-known French geographer, has received a concession from the Greek Government to carry out this design, and M. de Lesseps has promised his sympathy and such assistance as can be spared by one whose attention is monopolized by the more difficult and extensive scheme of Panama. When it is remembered how obvious the improvement effected by such a canal must at all ages have been to those enterprising peoples whose direct concern has been and still is the trade between the Adriatic and the Ægean and Black Seas, the only matter of surprise is that the operation has been so long deferred. When the power of Corinth was at its prime it was the one drawback to its happiness, the single element of weakness in its prosperity, that it was compelled to have two separate harbors, one for the Gulf and the other for the Ægean. With the view of mitigating, as far as possible, the inconveniences that arose from this circumstance, the Corinthians constructed across the isthmus a polished roadway over which vessels could easily be hauled, and, from the purpose with which it was built, it was called the Diolcos. After Corinth was destroyed by the Roman General Mummius (B. C. 145), and restored by Julius Cæsar, the Emperor Nero bestowed some notice on this once favored city, and devoted his attention to the question of cutting a canal through the isthmus. The ruins of the works which he caused to be erected are still shown. It is said that Nero wished himself to strike the first blow, or, as we should now say, lay the foundation stone; but a mutiny detained him in Rome. The work then languished, and either want of money, as reference to Suetonius would suggest, or the difficulty of piercing the hard rock, led to the abandonment of the design. The Emperor Justinian, who was imitated at later periods by the Eastern Emperor Emanuel, and also by the Venetians, erected fortifications across the isthmus; but no one attempted to renew Nero's abandoned canal. The fortifications did not avail to protect Corinth against either the Herulians or the Goths, whereas the canal would have added greatly to the welfare of that city and of the neighboring peoples. It is appropriate and auspicious that the formation of a modern Kingdom of Hellas should be so speedily followed by an attempt to perform one of the few tasks neglected by antiquity. With the cutting of a canal through the isthmus more will have been done to restore the prosperity of Corinth than has been even so much as attempted since the age of the Cæsars."

DISCOVERY OF A NEW AZTEC CALENDAR STONE IN MEXICO. — A correspondent writing to the Philadelphia *Bulletin* from Mexico says: "The most extraordinary discovery that has gladdened the hearts of Mexican antiquaries for years was made last Thursday by Captain Eavans, of Chicago. Under a dilapidated Indian hut, which stood on the place that once formed the favorite garden of the Texocan 'Poet-Prince' Netzahualcoyotl, Captain Eavans found a stone slab, eight feet by six, covered with hieroglyphs, and near the centre of it a clearly cut calendar, — similar to the far-famed 'Aztec Calendar Stone,' which is now attached to the cathedral in this city, and as to which, by the way, Señor Alfredo Chavero, an archæologist who has devoted three years to the study of the 'Aztec Calendar Stone,' contends that it was simply an altar dedicated to the sun god, and he has written a work to prove the correctness of his theory. It may be that the discovery made by Captain Eavans, taken in connection with the researches of the Mexican antiquarian, will lead to the development of interesting facts relative to the theogony of the Aztecan and Texocan deities. Fortunately Mr. Bishop, who is here sketching, happened to join Captain Eavans that day, and made a sketch of the slab a few minutes after it was exhumed. Señores Mendoza and Jesus de Sanchez, Directors of the Mexican National Museum, are in ecstasies over this archæological treasure, and are to-day making arrangements for its removal to the Museum. As King Netzahualcoyotl 'the Wise' built his palace on a hillock on which the residence of the sovereign lords of a more ancient nation had stood, it is probable that further researches in that locality may lead to interesting discoveries."

LIGHTNING-RODS. — A lecture was delivered lately at the Royal United Service Institution by Captain Bucknill, R. E., on the application of lightning-conductors to buildings and magazines. The lecturer, who has been employed in testing and inspecting a number of government conductors, especially drew attention to the following among other points: 1. The necessity of using continuous conductors with the smallest possible number of joints, and these joints carefully soldered. 2. The advantage of multiple points. 3. The necessity of using larger earth connections than is now usual, and of making some of them deep and some shallow. 4. The advantages of iron over copper conductors. 5. The unreliability of the so-called safe circle advocated by some electricians. 6. The advisability of providing a horizontal collecting conductor near the ground to connect the various earths with all the conductors, rain-water pipes, etc. 7. The want of periodical inspection and of testing the conductors electrically when they are properly put up. The lecturer exhibited an apparatus for testing conductors, as well as samples of both copper and wire ropes. For general purposes he recommended an iron-wire rope six pounds to the yard, and three pounds per yard when it was carried over the house to two "earths" on opposite sides. The equivalent ropes in copper would weigh one pound and one-half pound respectively, and cost about the same as the iron.

THE "AMERICANISTAS."— A society which has for its object the development by study and investigation of a knowledge of the geology, archæology, linguistic ethnography of the American Continent, and of its history before the discovery by Columbus, will meet at Madrid on the 25th of September. It will be under the patronage of the King of Spain, and is called the "Americanistas." The last meeting of the society was held in Brussels.

BUILDING INTELLIGENCE.

(Reported for The American Architect and Building News.)

[*Although a large portion of the building intelligence is provided by their regular correspondents, the editors greatly desire to receive voluntary information, especially from the smaller and outlying towns.*]

BUILDING PATENTS.

[*Printed specifications of any patents here mentioned, together with full detail illustrations, may be obtained of the Commissioner of Patents, at Washington, for twenty-five cents.*]

239,037. WATER-CLOSET. — Abraham Edwards, Philadelphia, Pa. In Letters Patent of the United States granted to the inventor, dated December 16, 1879, No. 222,578, is shown a mercury or rubber seal located below the bowl of a water-closet, and a sliding pipe connecting the bowl and the water-trap. The devices shown in said patent preclude the admission of all sewer gases coming from below the bowl; but it has been found by experience that fecal matter will adhere to the sides of the bowl despite copious flushing, and that such matter will generate offensive smells, which escape into the room. To obviate this the present improvement involves the movement of the bowl below the seal, so that the latter shall be above all except the seat and lid when the closet is not in use, the bowl being drawn up to the seat when the latter is occupied. The improvements still further relate to the construction of the bowl with a neck, which forms a conduit from the bowl proper to the trap below, when the former is raised for use, this neck extending down into the trap when the bowl is lowered beneath the seal-cap. This extension, which takes the place of the sliding pipe shown in the original patent, is cast in one piece with the bowl and enamelled like the latter. Serious trouble has heretofore been encountered with the valves of water-closets which are located outside the bowls, and out of communication with the discharge pipes, such valves often leaking, the drip flowing over the floor of the room, or through the ceiling below. The present improvements provide means for catching the drip from the valve and discharging it into the closet. Some objection has been made to mercury traps on the score of loss and danger from evaporation, and these improvements prevent such evaporation by keeping the mercury covered with water-drip from the valve. A indicates the floor. D is the ceiling below, and E an ordinary S water-trap between the floor and ceiling. F is a metallic section flange-bolted to the trap E at *e*, and of a capacity sufficient to receive the bowl of a water-closet, and in plan conformable to the shape of the mouth of such bowl. It has around its upper edge an endless trough *f*, designed to hold mercury, or a rubber strip. G is a cap hinged to the section F at f' and having a flange *g*, which is submerged in the mercury in the trough *f*. The cap G has also segmental cogged arms g' g'. H represents the bowl, which is formed with a neck, *h*, which extends down through section F, and when the bowl is lowered enters the trap E, as shown. It has vertical ribs h' h', with teeth or openings h^2 h^2; which mesh with the cogs of segments g' g'. The bowl H, when not in use, rests below the cap G, and therefore any smells which may proceed from fecal matter adhering to it will be prevented from escaping into the room, and will be carried off by the ventilating-pipe. In use the bowl is drawn up until its top edge meets the seat C, by raising the seat-lid C′, which has a rod-connection, I, with the winch *k*, on a shaft, K, which is a counter-shaft geared with the shaft G′. The latter shaft is the pintle of the seal-cap G. As the working space between the ceiling D and seat C is rather limited vertically, and as the width of the cap (which conforms to the oval shape of the bowl) is less than its length from front to back, it follows that it will be more advantageous to cause the cap G to turn up to one side of the bowl rather than to the back of it. To permit this and at the same time to allow the seat-lid to lift back in the usual manner, and in so doing to raise the cap and bowl, is the object of the counter-shafting. On lowering the seat-lid the bowl moves down into the section F, and the cap G closes over it, forming a seal or joint which prevents the escape of all gases and smells from the bowl or below. On the

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section F is formed a drip cup, L, which receives the drip from the flushing-valve *l*. The cup has an opening l', which is closed by a valve or pad, g^2, on the cap G when the latter is turned down. When the cap G is raised, the passage l' is open and the drip accumulations will flow into the mercury-trough. By this means mercury, if employed as the sealing medium of the joint, is kept constantly covered by water, thus preventing its evaporation. The overflow of water from the trough *f* passes into the bowl H, and thence to the discharge-pipe. The pipe M for supplying water for flushing and cleaning the bowl is stationary and affixed to the under side of the seat C, its outlet *m* being so arranged as to discharge into the bowl when the latter is raised, and produce a circular or swirling current.

240,908. DEVICE FOR CLEANING CISTERNS.—John

BUILDING INTELLIGENCE.

H. Keller, New Orleans, La. This invention presents a means whereby the inflow of water from the roofs of buildings drives the accumulations of dirt from cisterns. A represents an ordinary cistern, in which is secured, at any desired incline, a pipe, B, having a funnel-shaped mouth, C, that is held at a distance of an inch and a half (more or less) from the bottom of the cistern, as shown. The upper portion of the pipe is provided with an elbow or curve and passes out through the cistern wall at a point of about one or more inches below the top. The water from roofs of buildings passes through D into the cistern. When it reaches a height greater than that of the upper end of the pipe B, it naturally passes out through the same. The discharge, however, being from the bottom of the cistern, carries with it all sediment or foreign matters gathered around the mouth of the funnel C. When the water ceases to flow through this pipe, the remaining sediment gradually seeks its level, in this way bringing more material to the mouth of the funnel ready to be carried off by the next overflow.

243,056. ELEVATOR.—John H. Brown, Lynn, Mass.

243,058. HEAD FOR LATHES.—John Cain, Pittsburgh, Pa.

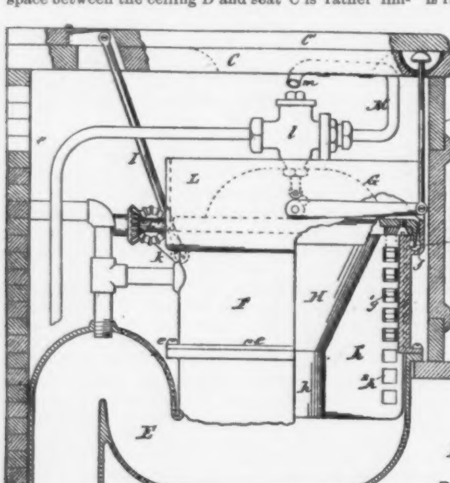

FIG. 1

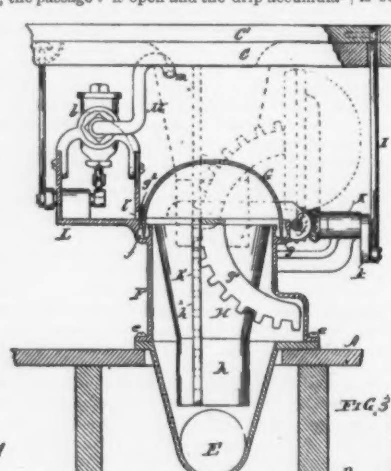

FIG. 3