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THE movement in favor of a World's Fair in Boston has taken shape in two public meetings at the Hotel Vendôme, held in accordance with a call signed by the chief officers of most of the mercantile organizations in the city, to consider the expediency of such an undertaking. The meetings were very fully attended, and although it was impossible to do more than appoint a committee to obtain definite information as to cost and other particulars, the general feeling was very favorable to the enterprise. The outlay for grading and preparation of the land would be trifling, and if circumstances should admit of utilizing the exhibition buildings of the Charitable Mechanic Association and the Manufacturers' and Mechanics' Institute, a very large item of expense would be saved, while the flat lands in and about the new Park present remarkable advantages of accessibility and central situation. By 1885, West Chester Park, which will bound one end of the site suggested, will undoubtedly be extended northward to Cambridge, and southward to Dorchester and Milton, while the main tracks of the Boston & Albany, including the New York & New England, and Boston & Providence Railroads meet at the opposite end of the grounds, and the Fitchburg road, by a branch through Newton of less than half a mile in length, could land its passengers at the same point. These four railways alone would bring a suburban population as great as that of Boston itself within thirty minutes' ride of the exhibition, while the street-car lines radiating in every direction from the building would make it a convenient stopping-place for passengers entering and leaving the city by all the different routes on their daily avocations. This is an important element in estimating the probable receipts of the Fair. A very large proportion of its patronage would come from the people of the suburban towns, and by making it easy for them to stay an hour or so any day without interfering with their business, repeated short visits rather than one or two long ones would be the rule among them, and their half-dollar admission fees would be correspondingly multiplied. Considering this, as well as the comparative wealth and populousness of the New England district, the estimate presented at the meeting, which set the probable number of admissions at five million, while the number at Philadelphia was eight million, seems a very low one, the more so as the summer climate of Boston is a cool and agreeable one, and the thousands of vacation excursionists from the West and South who flock to New England in the hottest weather would find no pleasanter place for their sojourn, independent of other attractions. Still, the thrifty Bostonians like to count the cost of what they intend to do before they begin, and it is very possible that circumstances may seem unfavorable to the enterprise. If so, it is best to find it out at this stage of the proceedings rather than later.

AFTER the discreditable stories concerning the Chicago Court-House and its architect, which have been industriously circulated of late, it is pleasant to read testimony going to show that some, at least, of the competitors for the work preferred to lose altogether the time and money which they had put into their drawings rather than purchase a favorable judgment at the sacrifice of their high conception of professional honor. Mr. Gay, who gained the second prize in the competition, is unfortunately in Europe, so that we have no means of knowing how his claim to succeed Mr. Matz happened to be passed over, but several architects assert that they were approached, soon after the competition, by persons professing to have influence with the County Commissioners, who offered to secure the commission for them in return for the promise of a certain sum, the payment of which should be contingent upon their success. Mr. Dixon was plainly told that his plan was placed among the first three, and that he could have it adopted by the payment of fifteen thousand dollars, but replied without hesitation that he would not give fifteen cents for any such purpose; that he went into the competition fairly, and would succeed fairly, or not at all. To Messrs. Burling & Adler advances were made in a more plausible manner, by a contractor, a friend of Periolat, who claimed to be influential with the Commissioners, and proposed to form a partnership with them, dividing the commission with them. Business arrangements of this kind are sometimes made by architects, and Mr. Burling not unnaturally consented to sign an agreement, of which, however, he repented immediately, seeing its doubtful character, and had it cancelled. Two other architects also testified to having been sounded by Periolat, who offered to obtain the commission for them in exchange for a promise of money, but both of them refused to listen to such overtures. One of these was Mr. Matz, who deserves the more praise for his honesty in that having already been awarded the first premium, and having personal friends among the Commissioners, he had good reason for believing that Periolat could accomplish what he undertook without difficulty and without suspicion. On the whole, supposing Periolat's story to be true, he seems to have had much trouble in finding an architect who would consent to accept the unfair advantage which he offered, and the investigation reflects credit upon the profession in Chicago rather than the reverse.

WE have received the Second Annual Report of the Executive Committee of the Archæological Institute of America, a document possessing a degree of interest quite unusual among such papers. The work of the Institute during the past year has been more varied, and if possible, more judiciously planned than ever, and although it is hardly yet time for the publication of definite results, the letters and reports of progress from the agents of the Institute are extremely interesting and valuable. Restricted in membership and resources as the society is, it has during the past year maintained or instituted explorations in four different places, by means of three separate parties, not working independently, but each occupying its own place in a general scheme of operations. At present, the Institute divides its energies between two objects, part of its force being directed to the investigation of American aboriginal remains, while the rest is devoted to the archæology of the Old World, particularly Grecian antiquity. In pursuance of the first branch of its work, a most efficient agent, Mr. A. F. Bandelier, of Illinois, spent five months among the Indians of New Mexico, living a part of the time in entire fraternity with them in the pueblo of Cochití, winning both confidence and affection among the simple people, and obtaining invaluable knowledge concerning their ancient customs and traditions. This scheme of investigation was intended to be a comprehensive one, embracing in regular succession the aboriginal tribes from New Mexico to the Isthmus of Panama, but on the invitation of the American director of the Lorillard Expedition, it was decided to change the order of exploration, and to send Mr. Bandelier to Mexico, where he could profit by the liberal appointments and conveniences provided by Mr. Lorillard.

IN the East the energy of the Archæological Institute has been not less successfully displayed. Our readers probably remember the interest which was felt in the departure of the expedition which is to make excavations at Assos, under the lead of Messrs. Clarke and Bacon, two young architects of Boston and New York, and will be glad to know that after various mishaps and delays the pioneers have safely reached their destination, and may reasonably look forward to a long season of successful work. Besides the Assos expedition the Institute was enabled last year, by the liberality of Mr. Henry P. Kidder, to employ Mr. W. J. Stillman as special agent in Crete, where there appeared to be a favorable opportunity for exploring the site of Gnossos and Gortyna, two of the most interesting cities of antiquity. Gnossos, particularly, besides being the scene of the primitive worship of Zeus, and the reputed place of his burial, was the royal city of Minos, King of Crete, son of Zeus and Europa, for whom Dædalus built the Labyrinth as a cage for the man-bull Minotaur, which, as the legend goes, devoured every year seven boys and seven girls, sent from Athens as a compulsory tribute, until the hero Theseus volunteered to be one of the victims, and threading his way through the Labyrinth with the aid of a clue held by the princess Ariadne, killed the monster and delivered his city from the tribute. Romantic as the tradition is, it is hardly more so than that of the siege of Troy, now established beyond question as an actual historical event, and Mr. Stillman's discovery of what appeared to him the entrance of the Labyrinth itself is of extreme interest. Unfortunately his previous friendship with certain political leaders in Crete rendered him an object of suspicion to the Turkish Government, and he was obliged to abandon his undertaking, to be resumed, we trust, at an early day. Much as has been done, infinitely more could have been accomplished if the Institute had been able to command funds for the work. The total number of members at present is but two hundred, and a large part of their annual contributions must necessarily be consumed in printing reports and papers. If the membership could be raised to one or two thousand, the income of the society would warrant it in undertaking much more extensive projects and obtaining more speedy results.

We have received a singular circular from the Cincinnati Association of Master Stone-Cutters, to the effect that on and after June 1, 1881, no member of that association will make any sub-contracts, or any estimates unless the plans, specifications and detail drawings are shown complete; that no estimates will be made except on condition that the bids are opened at a specified time in the presence of those bidders who desire to witness the operation; and, lastly, that all estimates shall be paid for at rates varying from one to two and a half per cent upon the amount of an average contract. Who is to pay this percentage is not specified, but the burden will practically fall upon the architects in many cases. It is unnecessary to say that the general enforcement of this preposterous demand, under which the architects of stone buildings, or their employers, would be obliged to pay more than the whole amount of their commissions for the privilege of trying to obtain a reasonable tender for a part of the work by comparing a number of estimates, would speedily result in the substitution of some other material for cut stone; and we suppose that the circular is really intended only to establish a latent claim, for the purpose of enabling disappointed bidders to give trouble by demanding compensation. In either case, the architects will be the first and the worst sufferers; and we advise all those who have, or are likely to have, cut-stone work to be executed in Cincinnati, to note carefully the names of the signers of the circular, and give them a wide berth.

A suit has been begun in New York to restrain the Metropolitan Telephone and Telegraph Company from erecting poles in the streets for the purpose of supporting its wires. This company has been lately organized, with the intention, it is said, of consolidating and controlling the telephone business in the city and its vicinity. In carrying new lines, poles have been set up in West Twenty-first Street, between the Fifth and Sixth Avenues, to the annoyance of the householders, one of whom applied for and obtained an injunction to restrain the company from continuing its work in the street, and brought a suit for damages, on the ground that the value of his property had been depreciated by the erection of the poles, and that he had found difficulty in letting his house on that account. A question arising as to the right of a private citizen to maintain such an action, the attorney for the aggrieved house-owner obtained permission from the Attorney-General to bring a new suit in the name of the people of the State, and a second injunction has been issued, to prevent further proceedings until the telephone company shall show by what authority they place such obstructions in the public streets. The order to show cause why the temporary injunction shall not be made perpetual is made returnable May 30, and the arguments and decision will be both interesting and important.

The Governor of Massachusetts has designated Mr. E. S. Chesbrough, of Chicago, and Drs. H. P. Wolcott, of Cambridge, C. F. Folsom and A. W. Boardman, of Boston, and Azel Ames, Jr., of Wakefield, to report a comprehensive plan for the drainage of the territory of and adjacent to the city of Boston, including the valleys of the Charles and Mystic Rivers. These appointments are made in pursuance of a resolution adopted by the Joint Legislative Committee on Public Health during the recent session, authorizing and requesting the Governor and Council to report a plan for the drainage of the Mystic valley, with an estimate of the cost thereof, and a recommendation as to the methods of apportioning such cost, and authorizing them in their discretion to include the Charles River valley and the immediate neighborhood of Boston in their investigation and plan or recommendation. This step is the result of the proposition for an extensive plan of drainage for the "Metropolitan District," including the towns within a radius of ten miles north and west of the city, to which we have before referred, and while our opinion is unchanged, that such a system of sewerage as was first suggested would be highly injudicious, we shall be glad to have the matter thoroughly discussed.

An important resolution has been passed by the New York Board of Underwriters in relation to the rapidly increasing use of electric lights in mercantile or manufacturing buildings. It is now proved that fires are liable to occur from badly insulated wires conveying the powerful currents of the electric lamps, and by the new rule all buildings in which the electric light is used, or over or through which wires for lighting by electricity may pass, will be rated as "specially hazardous," unless the wires are properly insulated and approved by the inspectors of the Board. Architects will do well to remember this, as these wires are very quickly run, and generally covered over immediately with plaster, so that a neglect to notify the insurance inspectors in time to have the work passed might place the owners in the unpleasant dilemma of having either to tear off the plaster for a subsequent inspection, or submit to an increased rate of insurance on their buildings and goods. Probably the companies will manage their inspection so as to place as few obstacles as possible in the way of a general use of electric lighting; for whatever may be the special risk of fire from electric currents, it is insignificant in comparison with the continual danger from the use of gas-lights, and no one reform would perhaps do so much to reduce the aggregate of fire losses as a general substitution of the incandescent wire or the voltaic arc for naked gas-flames and glass lamps filled with inflammable liquids.

The Panama Canal has fallen into a new trouble sufficiently serious to make it worth while for the citizens of the United States to be on their guard against hasty action in making so doubtful a speculation the subject of grave political movements. It seems that in accordance with the claims rather loosely made in the American Congress, and with what was understood to be the disposition of the people of Colombia, a protocol has been drawn up and signed by the representatives of both powers, providing that the canal, if it is ever built, is to be free to the ships of war and military convoys of the United States, either in peace or war, without payment of tolls; that the two powers shall in common select places suitable for forts, arsenals, coaling stations and naval storehouses, which shall be placed in charge of United States garrisons, sufficient only in time of peace for keeping them in a state of efficient service, but that in case the neutrality of the Canal is threatened the United States is to take military possession of the Isthmus, and Colombia will be obliged to co-operate. To the ships and munitions of war of all other nations except Colombia and the United States the Canal is to be closed at all times, although passage may by courtesy be granted to peaceful expeditions. Colombia is not to make or alter the regulations governing the use of the Canal without the assent of the United States. This agreement, although probably for the real advantage of Colombia, does not seem to have been well received. The Senate of that country has refused to ratify it, and popular feeling appears to be strongly against it. Meanwhile complaints are made that the actual work of excavation proceeds very slowly, so that political excitement will have time to subside before there will be anything at Panama worth quarrelling about.

THE agitation in favor of better communication between Boston and Cambridge has so far resulted in the formation of a new street railway company which proposes to lay tracks at once, connecting the portion of Cambridge lying nearest to Charles River with the Back Bay district of Boston, by means of a new bridge, continuing the line of West Chester Park. Once across the bridge a junction will be made with the great Metropolitan Railway system of Boston. The value of a direct route between the western suburbs and the Back Bay district is felt to be so great that overtures have already been made to the new company to extend its rails to Brighton, while a second company proposes to lay a track southward from Somerville to connect with those of the first on the Cambridge side of the river, so as also to make use of the new bridge. The extension of West Chester Park to Cambridge has been discussed for years, and the two cities would probably before long have united in providing a bridge, if private enterprise had not forestalled their action. However obtained, the new route of communication will undoubtedly have an important effect upon the future of both cities. Within a few months sites have been chosen for a considerable number of public buildings within the Back Bay region, hitherto almost exclusively devoted to dwelling-houses, and the importance to Cambridge of a means of reaching it speedily will increase with the number of such attractions, and at the same time the opening of a new channel for traffic with the heart of that region will stimulate the erection of hotels and theatres, and materially promote the westward growth of Boston.

"A BUILDER" writes to the New York *Journal of Commerce* as follows: "I am building some houses and have engaged an architect to draw plans and specifications for me, and all other arrangements, also to superintend the building. Now what I want to know is, whom do the plans and drawings belong to, the architect or me? He says they belong to him, and I think as I am paying for them they belong to me." The *Journal of Commerce*, quoting the Institute schedule, which prescribes that "drawings, as instruments of service, are the property of the architect," very properly replies that this custom would probably be recognized by the courts as governing the case. While ourselves quite agreeing with the view taken by the *Journal of Commerce*, we rather hope that its correspondent will not, and that he will press his claim to a judicial decision, for the sake of establishing a precedent for the protection of architects in future. The oppressive, and as we think unjust decrees by which in several cases architects have been suddenly deprived of property of great value to them, whose surrender they had not contemplated in their agreements with their clients, and without being allowed to fix any terms for giving it up, may naturally be supposed to have discouraged them from asserting their rights, and the prosecution of a claim so flagrantly improper as this of "A Builder," would probably result in a decision defining and establishing the limits of their duty toward their clients, in regard to which they have now to depend upon the fairness and courtesy which they can generally expect in their dealings with other men. According to the latest judicial decision on the subject, the plans drawn by an architect for the construction of a building belong to the owner of the building, "because it is contrary to public policy that a man should not have what he pays for;" the simple fact that he does not pay for the plans, unless by special agreement, but for the care and skill of the architect, who uses the plans only as instruments, being completely ignored. This circular argument has, however, a specious sound, and will probably continue to be quoted against architects until an attempt to carry it to its logical conclusion shall bring about a reaction. According to this theory there is nothing to prevent any man from pretending to employ a number of architects in the construction of buildings of a certain class, then demanding the drawings, and selling them to any builder who might desire to masquerade as an architect with the help of these borrowed plumes. The morality of such a proceeding is precisely analogous to that of an attempt by a dealer to buy a statue from a sculptor, for the purpose of having a mould made and selling duplicates for his own profit; or of a publisher, to hire a manuscript from an author, ostensibly for his own perusal, and immediately have it printed and sold for his private benefit; while the hardship to the architect is in some respects greater than it would be to a writer or an artist, since the plans of executed work are to him often of great value as memoranda by which he and his subordinates may be guided in subsequent constructions of a similar character.

A SINGULAR form of malarial disease is reported to prevail in Suffolk County, Long Island. While most other parts of the island are more or less subject to agues and intermittent fevers, this district is quite free from them, but is affected with a characteristic disease of its own, in the shape of lockjaw, which follows very frequently upon even a slight injury, and generally proves fatal. So well marked is this tendency that the inhabitants of that region usually kill at once any of their horses or other domestic animals that may happen to receive an accidental wound, however small, knowing from experience that this is the only way to save them from a more painful death; and persons suffering from any injury which breaks the skin are, if possible, sent away by physicians to recover in a more favorable atmosphere. Very recently, a prominent citizen of the county died of lockjaw resulting from a wound on the knee, caused by falling upon the ice, and within a month two other fatal cases have been reported, while a third patient is still under treatment. Whether any similar phenomena have ever been observed in other places we do not know, but the apparent connection of a serious disorder of the nerves with atmospheric influences is very interesting.

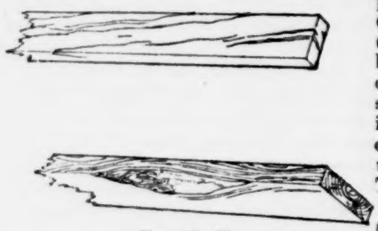
A BILL has been presented to the German Parliament, providing that all workmen employed in mines, quarries, building constructions, ship-yards, factories, mills and foundries, whose wages are less than five hundred dollars a year, shall be insured against accidents resulting from the practice of their trade, by means of a government establishment, under the supervision of the Federal Council, which shall fix the rates of premium. The insured, or their families, will receive indemnity in case either of their death, or disablement for a period of more than four weeks, and the premiums are to be paid partly by the insured, partly by the masters, and partly by the Government. For this purpose, all employers are obliged to render regular accounts of their business, the number of operatives under their control, and the amount of their wages. This economical device for extending government protection to the poor is, we believe, introduced by the ministerial party. That it would ameliorate the condition of the very poor is unquestionable, but the high-handed way in which it provides for compelling all persons of a given class to take out policies in the official insurance company is hardly pleasing to our ideas. Probably the expense to the Government of paying a share of the premiums would be little or nothing, since the profits of the business would suffice for this purpose; and the employers' portion must, of course, ultimately be paid by the operatives, so that these would actually bear the whole burden; while the Government, which pays the indemnity, would reap the advantage of its position as the almoner of such benefits, without really doing anything to earn it except compelling its subjects to save, whether they choose or not, a portion of their own incomes.

A PERMANENT Technological, Industrial and Sanitary Museum is to be established at Sydney, New South Wales, to take the place in the colony which the South Kensington, Bethnal Green and other museums occupy in London. The Acting Secretary, Mr. Charles R. Buckland, invites contributions of animal and vegetable products, from the raw material through the various stages of manufacture to finished goods; specimens of economic geology and entomology, showing metallic ores in various stages of preparation, building and ornamental stones, clays and cements, and in the department of entomology of the various insects which are useful or injurious to man, presenting their stages of development and indicating the means by which they are nourished or destroyed; models, plans and specimens of tools, sanitary appliances, machinery and furniture, including decoration and artistic work of all kinds; educational apparatus and appliances, school fittings, maps, books and diagrams, and photographs or other reproductions of such interesting objects as cannot be obtained in the original. Besides these, a particular request is made for exhibition catalogues, trade journals and price-lists. No expense is incurred by those who send contributions, and freight is paid by the Trustees of the Museum on the arrival of the goods in Sydney. It is proposed to place the collections in the present International Exhibition Building at Sydney, and the names and addresses of the manufacturers, with the prices of the goods, may be attached to all exhibits.

BUILDING SUPERINTENDENCE. — VI.

The water-table indicates the level of the main floor, and while preparations are making for laying it, the beams may be placed in position. Stock for these has been delivered at intervals previously, and carefully examined, several loads having been rejected for containing timbers *considerably* less in size (since the timber shrinks after sawing) than the specification calls for, while others have been thrown out on account of pieces badly "shaken" (Fig. 46); or "waney" (Fig. 47), through having been sawed too near the outside of a crooked piece, so that a part of the wood is lacking; or weakened by large knots near the middle of the span. The nave and chancel floor beams are divided in to two spans, the inner ends of each span being carried on a line of girders running through the middle of the building, and supported by brick piers under the nave, and an iron column in the society-room under the chancel. The girders of main floor are of Georgia pine, eight inches by ten, those in chancel being eight by twelve, and all are already on the ground. It is necessary to have these properly set before the beams can be put in position; but if the piers were to be built up first, and the heavy timbers laid upon them, there would be danger of overturning or displacing them, so it is best to support the girders by temporary wooden shores until the floor is on, and afterwards build up the piers between the shores. As there is ample head-room in the cellar, the beams are simply notched upon the girders, instead of framing them in, and thereby weakening the girders with mortises.

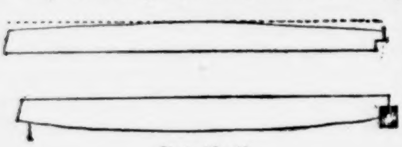
Flooring Timber.



Figs. 46, 47.

The carpenters are already cutting the notches, and the foreman hastens after us to ask whether he shall "crown" the beams, and if so, how much. Nothing is said about it in the specifications, and a little reflection is necessary before a reply can be given. The crowning, as now usually practised, consists in trimming off with an adze the upper edge of the beams, so as to form a curve, the convexity of which may be one inch or more, as required. (Fig. 48.) Nothing is taken off the middle of the timber, so its strength to resist a distributed weight is not impaired, and as all ordinary beams sag a little under their own weight, and still more when loaded with flooring and plaster, the crowning enables this sagging to be compensated, and such a beam, when suspended at the ends, will be level or slightly convex on top, the bending due to the weight showing itself on the under side. (Fig. 49.) Formerly the same effect was sought by shoring up the beams strongly in the centre, so as to bend them upward, and then either building them into the walls, or confining them by timbers placed against their ends, and connected by iron tie-rods passing between the beams (Fig. 50), but this method is objectionable, and is now rarely used.

"Crowning."



Figs. 48, 49.

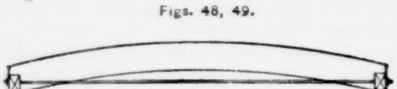


Fig. 50.

In order to determine whether crowning by the other mode is desirable, we can easily calculate the probable bending of the timbers, or, what will be still better, experiment on the spot, by placing one of the beams, the top of which has been previously ascertained to be straight and true, on supports at the proper distance apart, and loading it at the middle with a weight equal to *half* the load which will come upon it after the building is completed. In this case the beams of the main floor are of spruce, three inches by ten, and of chancel floor three by twelve, all placed sixteen inches from centres, and twenty feet long, the clear span being nineteen feet four inches. They will be plastered one heavy coat underneath, and covered with a double boarding. Each beam carries the whole weight of the flooring above it and the plastering below it, from the central line of the interval between itself and the next beam on one side to the corresponding line on the other side, the distance between these two lines being the same as that between the centres of the beams themselves, or sixteen inches. Each beam will then sustain, independent of its own weight, an area of flooring 16 inches wide and 20 feet long, and an equal area of plastering, amounting to 16 inches ($1\frac{1}{3}$ feet) $\times 20 = 26\frac{2}{3}$ square feet of each. One square foot of dry pine board an inch thick weighs about three pounds, and as the boarding is double, six pounds will represent the weight of flooring per square foot. Plastering of the kind mentioned will weigh about six pounds per square foot, making a total load per foot of 12 pounds, which multiplied by $26\frac{2}{3}$ will give 320 pounds as the distributed load on the beam, exclusive of its own weight. One-half of this, or 160 pounds, applied at the centre will produce the same effect as the whole distributed load, and by loading our experimental beam in this way the amount of bending can be at once ascertained. A bucket hung over the middle of the beam, and loaded with thirty-five to forty bricks according to size, or with a man standing in it, will form a ready means of applying the weight, and a string tightly stretched between the ends of the beam will show the deflection, which we find in this case to be less than a quarter of an inch. So slight a deflection is not worth the trouble of correcting by crowning the beams, especially as the bridging of the floor, which is required by the specification, affords protection against *unequal* deflection; and we therefore inform the foreman that it will not be required. The tops of the beams must, however, be well levelled; and as they are likely to vary somewhat in depth, the gauge for notching them to fit upon the girder must be taken from the *top*, not from the bottom edge. The ends which rest on the walls need not be notched, but are "pinned up" with chips of stone or slate to the required height. Wooden chips must never be used for this purpose, as they soon rot out, and allow the beam to settle.

Concerning the manner in which the beams should be built into the wall, there is much diversity both of opinion and practice. On one point, however, all are agreed; that the ends should be cut on a bevel, thus (Fig. 51), the variation of the inclined line from the vertical being two to four inches, according to the depth of the beam. The object of this is to prevent the destruction of the wall, in case of fire, by the fall of the floor when burnt through. If the beams are bevelled

Bevelling Ends of Beams.

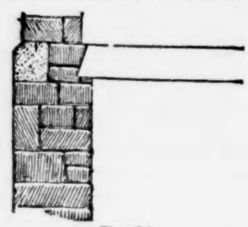


Fig. 51.

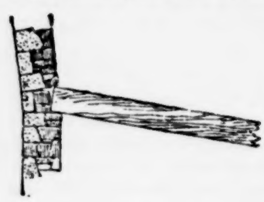


Fig. 52.

as shown, they drop out quietly when their outer ends are consumed; but if left square, the portion in the wall acts as the short arm of a powerful lever, whose outer end, being depressed as the floor falls, pries the wall outward with immense force. (Fig. 2.) But besides this, precaution should be taken lest the ends of the beams absorb moisture from the foundation and perish by dry-rot. The most important security against this is the avoidance of dampness in the cellar and its walls by the precautions suggested above, without which the other expedients avail little. If reasonable dryness is maintained about them, sufficient further protection can be obtained by leaving a small open space about the ends of the timbers for circulation of air. Some simply build up vertically behind the ends of the beams, filling in solidly between them, and trusting to the subsequent shrinkage of the wood to open a slight but sufficient communication between the triangular hollow behind the timber and the air of the cellar. Others increase this communication by tacking a piece of zinc or felt paper over the end of the beam, letting it hang down at the sides, so as to keep the masonry at a small distance from the wood. Still more careful constructors build up a recess around each timber, leaving it free on all sides, but with a dry foundation of hard stone, laid in half cement, and the floor two feet or more above the ground, so great precaution is unnecessary except for heavy girders. In the present case, being very confident of the dryness of our wall, we will compromise by filling in closely between the beams with the stone-work, but will leave a space behind them, and will span the end of each beam by a stone or a couple of bricks, so as to open a communication above the beam between the interior space and the air.

Protection against Rot.

When the first tier of beams has been laid and the ends built up with masonry, the work of the superstructure may properly be said to begin, and a variety of new cares will come upon us. Here also commences a considerable divergence between the practice of different localities in respect to many details of construction. In the Eastern States, and to an increasing extent in others, the next step after laying the first-floor beams, and bringing the walls up to a level with them, is to cover the whole floor with cheap inch boards of hemlock or spruce, generally "thicknessed," — that is, planed on one side so as to reduce them to a uniform thickness, and firmly nailed down in place. This furnishes a convenient starting-point for future operations; materials are stored upon it, the roof is framed upon it, stagings are erected on it, and the men move freely over it.

Superstructure.

Under Floors.

Whenever it becomes necessary to reach the space between the beams, for nailing bridging, running gas-pipes, or other purposes, a board is easily taken up and replaced again, and at the very end of the work the whole is brushed clean, the holes and broken places repaired, and an upper flooring of new, clean, fresh boards put down over it, one or two thicknesses of soft felt being laid between, making a strong, handsome, impervious floor. Among the old-fashioned builders in New York and other places this method is thought unreasonably costly, and a single flooring only is used, generally of one and a quarter inch boards, the laying of which, of course, in order to preserve them from injury, is delayed as long as possible, all the operations of building being meanwhile carried on over a skeleton of beams, traversed in different directions by lines of planks which have continually to be taken up and changed, while supplementary planks must be brought and laid down to hold all the material used in each story, and if a tool is dropped, or a bolt or anchor-iron rolls from its place, it descends to the cellar, where the workman must go to find it, or let it be altogether lost. To one familiar with both systems, the latter seems to involve a great waste of time and labor, and the testimony of the best builders is that the double flooring, though costing more for material, is so much more economical in these respects as to save more than its extra cost in the completed building.

We find this construction specified for the structure under our charge, and in less than a day after the beams are on and levelled, they are covered with a smooth, firm floor, which can be put down with extreme rapidity, being laid without much attempt at unnecessary neatness. The boards, being of hemlock, are full of shakes; some are cracked in a dozen places, while in others the annual rings have separated, and can be peeled off by layers. Some hemlock lumber is much better than this, but there is no need of being very particular. As soon as convenient after laying the floor, the boards are taken up in a line through the places marked for bridging the beams. There are to be two rows of bridging in each span, but the kind is not specified. Occasionally a builder is found who imagines that a floor can be bridged by fitting in square bits of plank between the beams and nailing them in place; a device as costly as it is perfectly useless, the planks answering no purpose whatever except to burden the floor. The proper way is to fit in strips diagonally between the beams, of sufficient length to reach from the upper edge of one to the lower edge of the next, nailing them firmly in place with two large nails at each end. (Fig. 53.)

Bridging.


Fig. 53.

A double row is necessary, so arranged as to abut in pairs against the upper and under sides of each beam, and the effect, if arranged as they should be, in lines made perfectly straight, marking the position of each piece by a chalk-line on the edges of the timbers, is to connect the beams together by a kind of truss (Fig. 54), which prevents any one from bending downward without carrying down with it a number of others, greater or less according to the perfection of the workmanship, but ordinarily about ten. Nothing is added to the absolute strength of the whole floor, but any single overloaded beam is enabled to divide its burden with six or eight of its neighbors, which is a great gain. The bridging in important buildings is usually specified to be of two-inch by four-inch pieces, and such may sometimes be necessary; but for ordinary dwelling-house beams, not more than sixteen inches from centres, strips one inch or one and a quarter inches thick and four inches wide will, if well fitted and nailed, prove quite sufficient.


Fig. 54.

Tying Beams. The ends of the beams which rest on the girders should be nailed in place, and in addition "dogs" of round bar-iron three-fourths inch in diameter and about eighteen inches long, turned down at each end and fashioned into a rough, chisel-like point (Fig. 55), should be driven into the abutting ends of two opposite beams, at intervals of about eight feet, the whole length of the building, so as to connect the beams strongly together; and wall anchors of flat bar-iron, one-half inch thick, and at least one and a fourth inches wide, not less than four feet long, and turned up four inches at the end, should be spiked, by means of holes punched for the purpose, to the wall end of the same beams that are tied at their other ends to the beams beyond, leaving the turned-up end to be built into the masonry of the wall above the water-table. This end is often split into a fork and each branch turned up, much improving its hold, and the inner end is sometimes turned down and driven into the beam, besides being spiked to it. These different anchorages form a continuous tie from wall to wall, and although not far from the ground, will assist materially in keeping the masonry upright.

Wall Anchors.

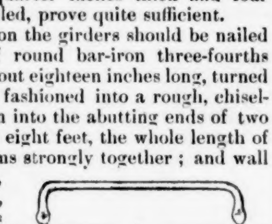


Fig. 55.

Other anchors must be provided, for tying the angles of the building in the superstructure. These should be of iron similar in thickness and width to those just described, turned up at one end and down at the other, and from four to six feet long. They should be laid alternately in each of the walls forming the angle, and at intervals of from four to eight feet in height, according to the amount of bond obtained by the stones alone. Young architects are often surprised to find that so much iron is needed in masonry, which they imagine by the descriptions given in their text-books to be quite capable, when well bonded, of holding itself together without such aid; but our ordinary structure of thin ashlar facing, backed with incoherent rubble of small stones, is a very different matter from the combination of squared blocks to which the books refer.

Ties for Hollow Walls. Still another set of anchors must be built into certain portions of the walls as they progress, to hold the brick lining which is subsequently to be built up inside. A part of these are to be used in the society-room under the chancel, and others in the vestibule which forms the first story of the tower. The former of these lining walls is to be plastered, but not the latter, and the anchors needed will differ a little in consequence; those for the plastered wall being arranged to project entirely through the lining, turning up two inches on the inner side, while the others must stop just behind the inner face, so as to lie concealed in the joint. They should be made of iron not less than one-sixteenth inch in thickness and one inch wide, tarred or galvanized, turned up at the end in the outside wall, and extending halfway through it. They are to be built into the outside wall at intervals of two feet both horizontally and vertically, setting them carefully to the proper length by measuring from the *outside*, and left projecting until the time comes for building the lining wall, when they will be found all ready at the proper place. Various forms are given to these ties, all intended to prevent condensed moisture, or water driven through the outer wall, from being conducted by them across the air-space into the lining wall, where it would show itself by a permanent spot in the plastering. The part which crosses the air-space is often bent downward into a V-shape, from which the water drips to the bottom of the cavity, and this, if the depression is deep enough, is moderately effectual, but if too shallow, the mortar falling from above collects on the ties in quantity sufficient to bridge the air-space in some places, and convey water through to the lining. Another form is made by twisting the ties so that the portion in the air-space is vertical, and collects neither mortar nor water. The iron is sometimes used without twisting, but set in the vertical joints, thus attaining the same result at less expense, but with greater trouble; since the irons, being set at random in the wall, never coincide exactly with the joints of the brickwork, and have to be bent more or less to reach one. When inserted in the horizontal joints, little bending is necessary, hardly more than an inch in any case; but when placed in the vertical joints, the lining wall being composed entirely of stretchers, a lateral movement of four inches may often be required. On the whole, the V-bent ties seem to be most suitable in our case, but we direct that they shall be placed vertically one above another, so that those above may shelter those below from falling mortar, and that in building the lining every row shall be cleaned off as soon as the one above it is fixed in place.

Freestone. While these matters are being settled, the delivery of freestone, both cut into ashlar for the facing and in rough blocks for working into mouldings and arch-stones, has been going on. This should be attentively watched, and if possible a visit should be made to the quarry to inspect the different beds of rock. There is usually much variation in the quality of stone from the same quarry, one end frequently running into extreme hardness, while the other is too soft for use, or superposed strata may show different properties. Variations in color usually accompany differences of texture, and each different tint of stone on the ground should be tested by chipping off a thin piece, and crumbling the edge in the fingers. The hardest sandstone will resist this treatment like flint, but most building stones crumble slightly at the very edge, while the poorer varieties crush easily. Few of the ordinary freestones show a much greater hardness than common loaf sugar, but those that are softer should be rejected.

Sand-holes. Some kinds of stone have an extremely annoying defect in the shape of "sand-holes," which are small formations in the interior of the block, often similar in appearance to the rest of the stone, but destitute of cementing matter, so that on being exposed by cutting, the sand falls out, leaving an unsightly hole, which cannot be successfully concealed by filling with cement. Any variety of stone which proves to be affected in this way should therefore be entirely rejected, as sand-holes may exist in any of the blocks, undiscovered until the stone is cut. Some stones contain similar cavities filled with clay, which are equally pernicious.

Seams. Seams injure the quality of many classes of freestone, but are usually more easily detected than those in granite. All sandstone is stratified, the beds varying from ten feet to a small fraction of an inch in thickness, and the divisions between the strata show themselves as dark streaks on the edge of the stone. Where the beds, though distinct, are strongly cemented together, the stratification rather improves the quality of the material by the beautifully figured appearance which it gives to a smoothly-rubbed surface, as in the stone from Portland, Connecticut, but the seams are not always tight, or if they are, may not remain so, and the stone scales or "shells" away, so that blocks, especially large ones, of stratified rock should be "sounded" all over with a hammer before setting in the building, to detect any separation between the interior surfaces.

The stone-cutting shed will now become a point of special interest at each visit, since here will be carried into execution the ornamental details of the building, whose accuracy and perfection of workmanship will do much to enhance its beauty.

Jamb-stones. Among the first things done in the cutting-shed are the jamb-stones for the windows. The sills are to be slip-sills; that is, inserted between the jambs at some subsequent period, and the detailed sections of them are not yet at hand, but a number of jamb-stones are cut. We have taken care to make ourselves perfectly familiar, not only with the position, height above the floor, and exact dimensions of every window, but also with the depth of the various reveals; and we begin at once to measure the smaller stones to see if they are of the required depth, finding immediately that many fall short an inch or more. These must be marked and laid aside, to be recut for other purposes, making sure that they are not likely to be put into the wall, for the replacing of an unsatisfactory quoin is a disagreeable matter, and it is still worse to leave it in and endeavor to fill out the deficiency by patching.

The other details should be sharply looked to; sketches made to explain obscure drawings; the moulded work frequently compared with the zinc patterns or templets, and these with the sectional drawings; the carving criticised, and the straight-edge and square frequently applied to the work of men who seem unskilful or negligent.

The regular routine of a tour around the outside of the building, followed by one inside, and an examination of the new materials, first inside and then outside, should still be kept up, but the inspection should take place at the level of the staging where the men are at work. The steel rod may occasionally be used to examine the workmanship of new men, and a continual watch must be kept to see that the ashlar is properly and sufficiently anchored to the backing, and that all exposed angles or projecting parts of the stone-work, as corners of openings, string-courses, sills and cornices, are well covered up with boards, to protect them from accidental blows, and from falling objects.

Before the walls reach the top, it is necessary, whether the specifications mention it or not, to build in long bolts at every angle, and at intervals of about ten feet along the walls, to hold the wooden wall-plate. The bolts should be of one-inch round iron, three or four feet long, with a short plate at the lower end to give them secure hold, built in vertically, so that the upper end, threaded for a nut, may project an inch at least above the top of the wall-plate when laid. In setting this, holes are bored for the bolts, and nuts with large washers are put on and screwed down firmly.

Anchoring the Plate.

The setting of the cornice and coping stones must be watched anxiously. It is customary to specify that all cornice or other projecting stones shall balance on the wall, or in other words, that the weight of the portion of the stone on the wall shall exceed that of the projecting part, by one-fourth, one-half, or more, as the case may be. Whether specified or not, a considerable excess of weight on the wall is necessary to a good job of stone-work. Heavy cornice-stones are often seen, where the vigilance of an inspector is wanting, which would fall immediately into the street if they were not held back by thin iron straps to the timbers of the roof, and do so fall when the straps rust, or the timbers are burnt away.

Cornice-Stones.

Copings must also be strongly secured against sliding off. The "kneelers" or corbels at the foot of the slope, which ostensibly support them, are seldom so designed as to be capable of anything more than holding themselves in place, and usually require even for that to be anchored back to the masonry, so that the coping-stones must be held by irons at the foot of each. Finials also, which commonly decorate the peaks of gables, are not secure unless dowelled to the adjacent stones, and if composed of several pieces should be drilled completely through, and strung upon a long iron rod previously built into the masonry, with nut and washer at the top to hold the joints firmly together.

Copings.

Finials.

The young superintendent will hardly see the finials placed on his building without having undergone several conflicts with the contractor as to the stones which are to be permitted in the work. He may find his orders about seams and sand-holes cheerfully complied with, but stones accidentally broken after cutting will be used wherever they can escape his eye; the fractured portions, if conspicuous, being neatly cut out, and a new piece inserted and glued in with melted shellac. In dry weather, and while still fresh from the tool, such patches are hardly noticeable unless near the eye, and they should therefore be looked for from the stagings before these are shifted; but when the stone is wet by rain, the inserted piece becomes painfully conspicuous, and as the shellac is slowly destroyed between the stones, the joint becomes more and more evident, and the piece may even drop out if situated, as sometimes occurs, on the under side of a lintel.

Patched Stones.

Both firmness and consideration are necessary in dealing with these cases. While a patched jamb-stone, sill or lintel, unless of extraordinary size, is inexcusable, it would be harsh to condemn a piece of rich and costly carving for a small mutilation which could be easily concealed; and some fractures may occur after the stone-work is completed which can only be repaired by patching in this way. The walls are by this time ready for the roof, and the tower has been carried up to the same height. The contractor, anxious to save all the time possible, is still at work on this, although the season is getting late, and the nights frosty. One unusually cold morning we arrive on the ground, and find the mortar left over from the previous evening frozen hard in the tubs. Trying one of the small stones in the backing laid the day before, we find that instead of adhering to the mortar, and bringing away some lumps clinging to it, the stone separates easily, and comes away clean, while its surface, as well as that of the mortar in which it lay, is covered with hoar frost.

Mason-work in Freezing Weather.

This is a plain indication that the mason-work must be suspended until the settled warm weather of spring. The film of frost which penetrates in cold weather between the mortar and the stones forms a complete separation, and adherence does not take place again after the ice is thawed, while the mortar is itself also more or less disintegrated by freezing. Mortar of pure lime, if frozen in the tubs, may be warmed and worked over so as to be used, but cement, if its first set is once broken up, either by freezing or by unnecessary stirring, will never harden again.

The foreman, mindful of his master's interests, resists the order to cover up the walls, relating anecdotes of structures built without harm in the midst of terrible frosts, and urging at great length the well-known superiority of a "frozen set" over all others; but he should be overruled. If any error is committed, it should be on the side of safety. It is true that *plastering*, of pure lime only, if frozen at the beginning of the season, and kept constantly frozen for some months, acquires at the end of that time a considerable hardness, which is not lost on thawing; while if thawed within a few days or weeks after freezing, it disintegrates and crumbles; but in this there is no question of the separation between the stones or bricks and the mortar of a piece of masonry, which takes place without regard to the duration of the freezing, and constitutes the chief danger, and moreover a "frozen set" is impossible with mortar containing cement or hydraulic lime.

Frozen Set.

The tower walls are therefore covered with a roof of boards, and the masons sent to cut stone for the spire, or employed in building the basement piers, and as soon as the main roof is on, the lining walls in the society-room and vestibule.

The design for roof trusses should have been anxiously criticised by the superintendent, in order to detect and remedy the weaknesses, if any exist, before they cause loss and discredit through the failure of the executed structure.

Roof.

If all is found satisfactory, the details are committed to the framer, who will probably need and ask for advice concerning the various joints, tenons, bolts and straps, so that the young architect will do well to refresh his knowledge on these points both from his text-books and such examples as he can reach. The accuracy of the curves, the neatness of the chamfers, the sufficiency of the bolts, should all be noted, as well as the correctness of position on the walls, and the alignment of the purlins. The rafters once on, the covering-in commences immediately, and after inspecting the quality of the boards, which should be planed on one side, smooth, straight-edged and free from loose knots, if slate are to be laid over them, it will become necessary to decide as to the best way of working the flashings and gutters. Of the former, there will be not only the valleys, but the intersections of the roof with the back of the gable walls, the tower, and two chimneys, which must be protected against the entrance of water. The specification requires "all necessary flashings" to be put on "in the best manner," carelessly omitting further details. Even the material which shall be used is not specified, and the superintendent wisely resolves to come to an understanding with the contractor beforehand, and thus avoid the possibility of having to reject work after it has been put up.

Flashings.

Unquestionably, the "best" material for flashings is copper, which is indestructible by weather, is so tenacious as not to crack like lead or zinc when bent at a sharp angle, and so stiff that after bending it cannot be, like lead, blown up by a strong wind. Nevertheless, copper flashings are costly, and little employed, so that it would be unjust to require a contractor to use them under the circumstances, and we must content ourselves with lead and zinc. The latter metal will constitute the whole of the valley and hip flashings, and two ways of arranging these are permissible; the best practice of various localities inclining about as much to one as the other. Often the two systems are mixed, and the valleys laid by one, and the hips by the other, or *vice versa*.

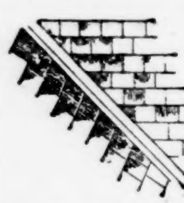
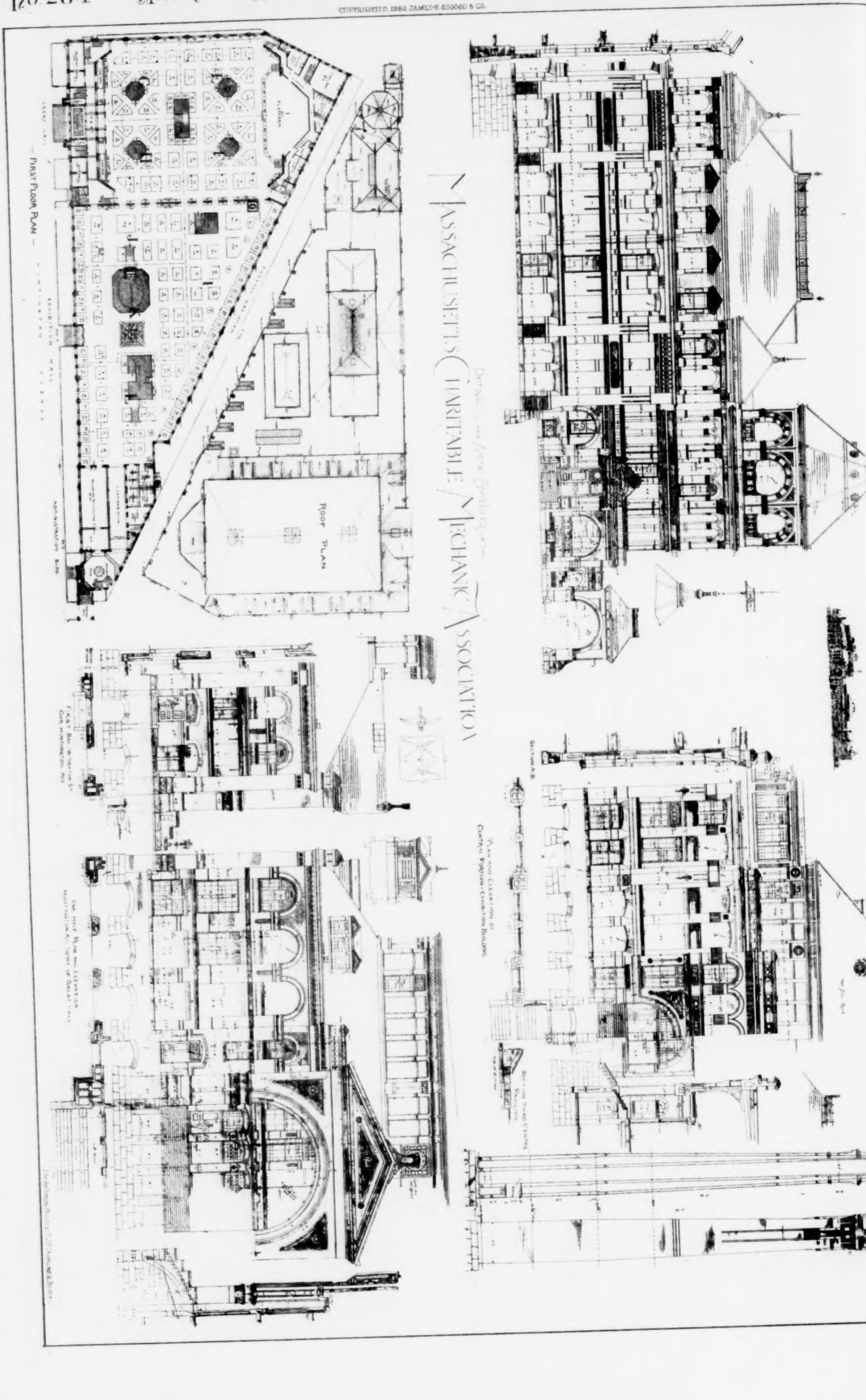


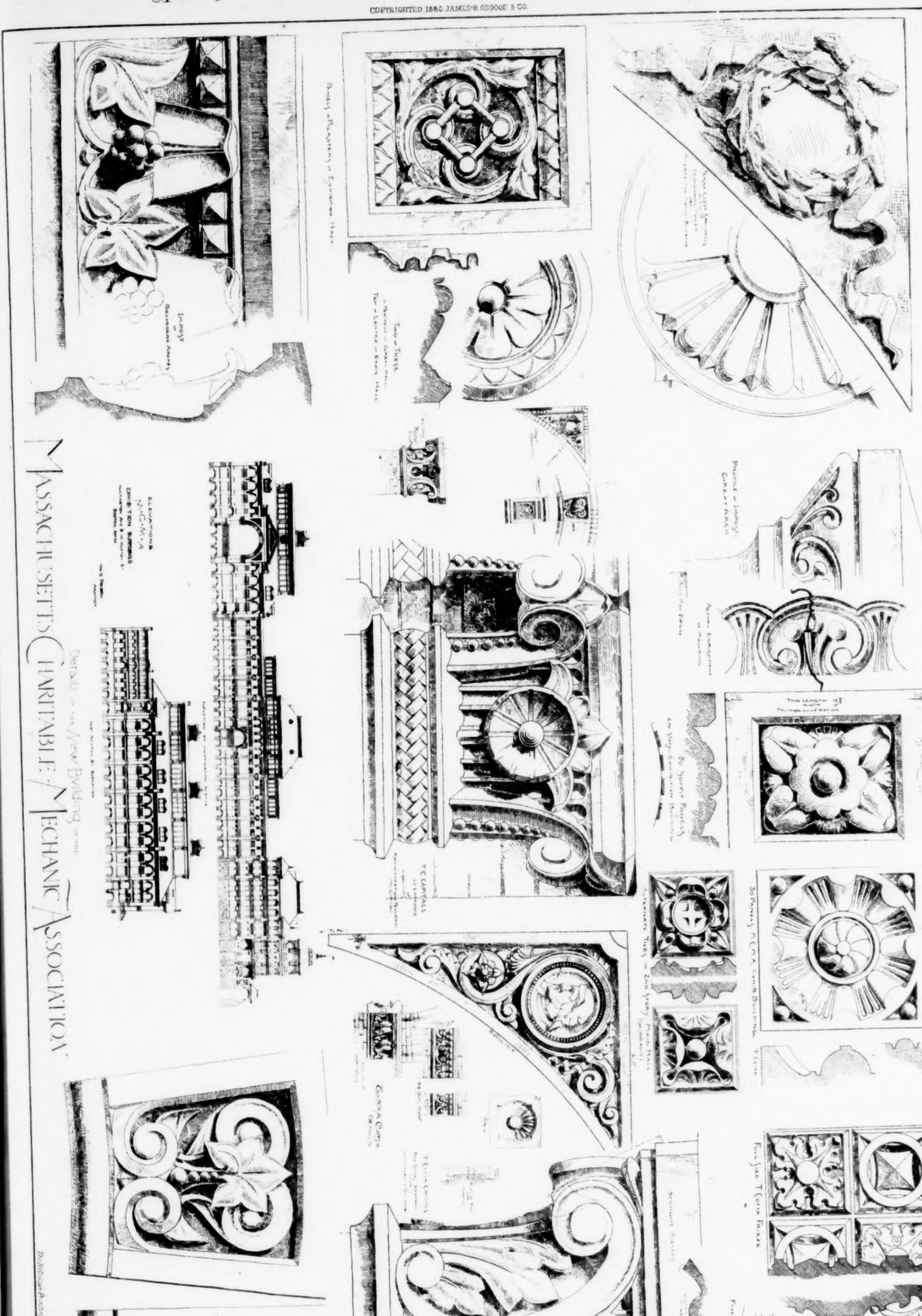
Fig. 56.

Fig. 57.

Fig. 58.

By the first method, which is perhaps most popular in the large cities, the valleys are covered with a long strip of zinc, fifteen or sixteen inches wide, laid the whole length of the angle, and soldered together at the joints (Fig. 56). This is tacked at the edges, and the slates laid so as to lap over it on each side. If the metal were not subject to expansion by heat, this would perhaps be the best way; but the long strips lengthen very sensibly under a summer's sun, to contract again in winter, and the ultimate effect often is to tear them at some point, making a bad leak. The same method applied to flashing against a wall consists in covering the joint by a long strip, one edge of which is bent over, and tucked into a reglet, groove or "raggle" cut in the stone or brick work of the wall six inches or more above the slope of the roof, and parallel with it. The efficiency of this depends on the care with which it is done. The effect of alternate heat and cold on such a flashing is to warp it until it springs out from the "raggle" either at one end or in the middle, letting a


Massachusetts Charitable Mechanic Association
Roof Plan
— First Floor Plan —


Details of the New Building of the
Massachusetts Charitable Mechanic Association

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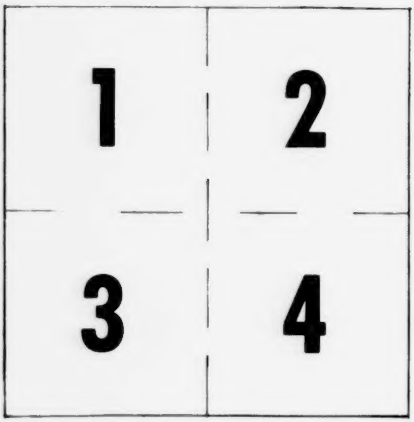

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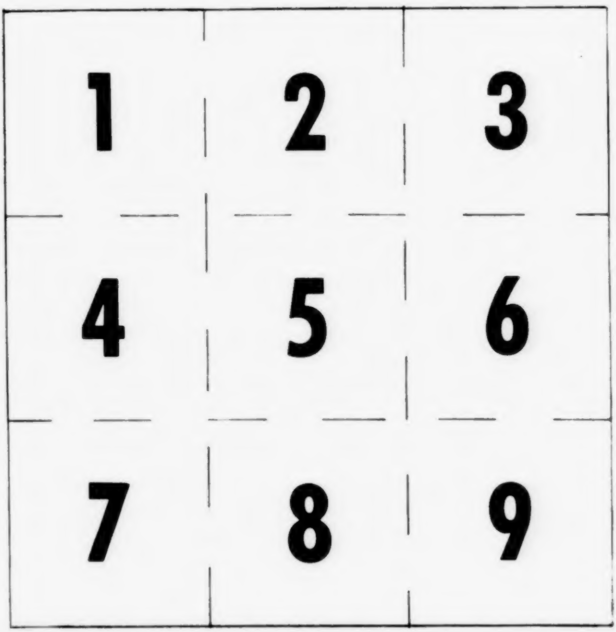
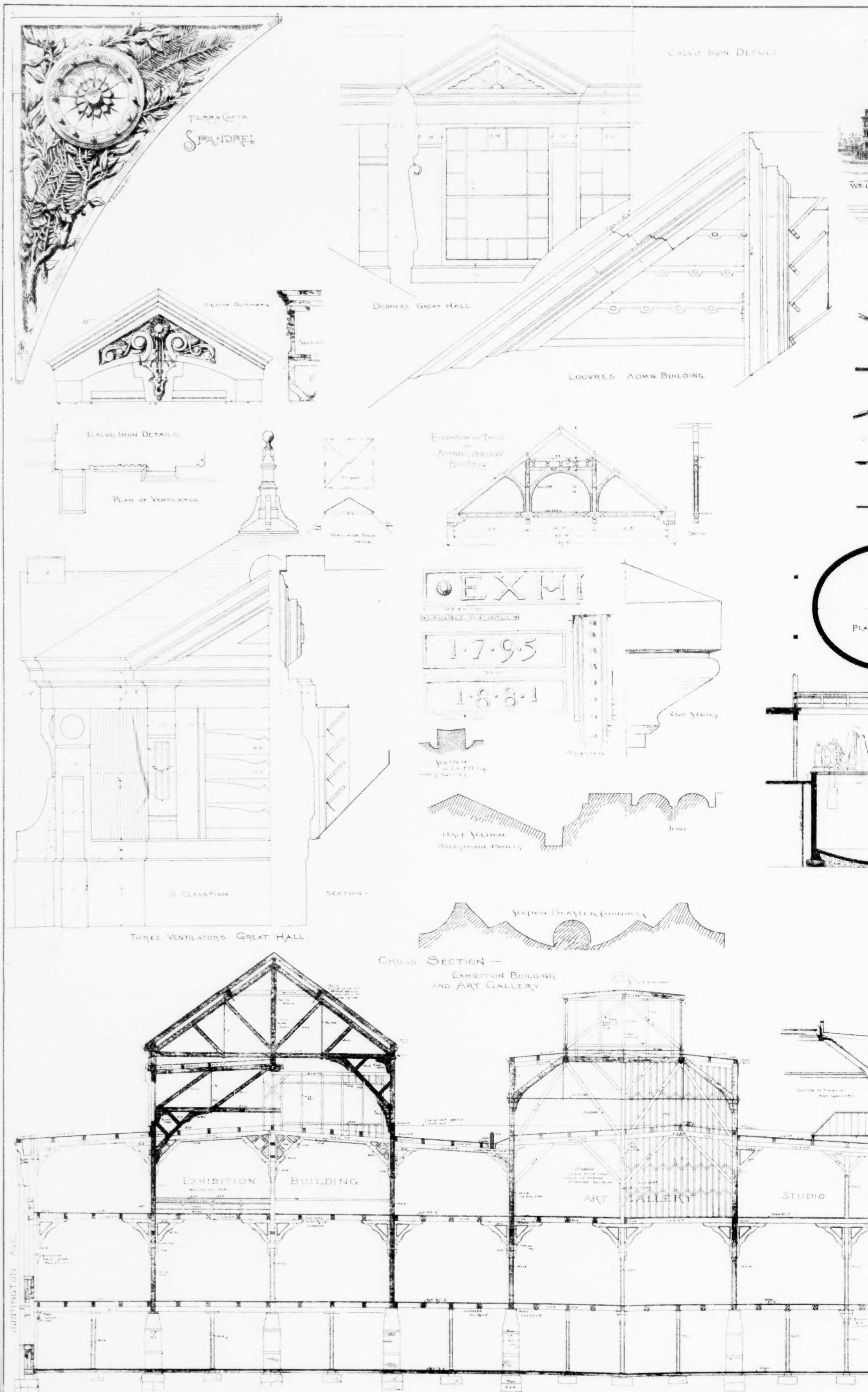
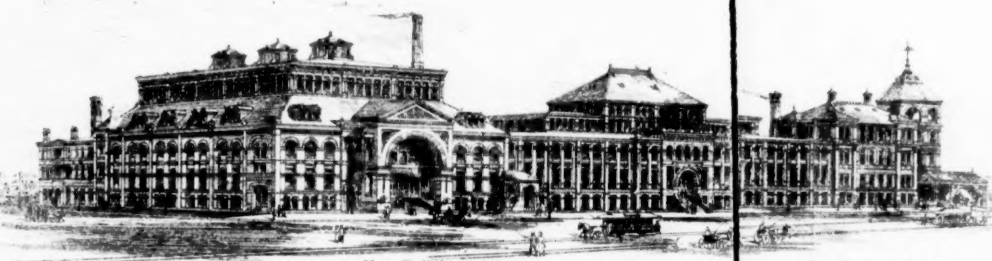




TERRA COTTA
SPANDREL
GALVD IRON DETAILS
DORMERS GREAT HALL
LOUVRES ADMN BUILDING
GALVD IRON DETAILS
PLAN OF VENTILATOR
EXHI
1·7·9·5
1·8·8·1
2ND STORY
HALF SECTION
BALUSTRADE PANELS
JOINT
½ ELEVATION
SECTION
THREE VENTILATORS GREAT HALL
CROSS SECTION —
EXHIBITION BUILDING
AND ART GALLERY
EXHIBITION BUILDING
ART GALLERY
STUDIO
HUNTINGTON AVE.

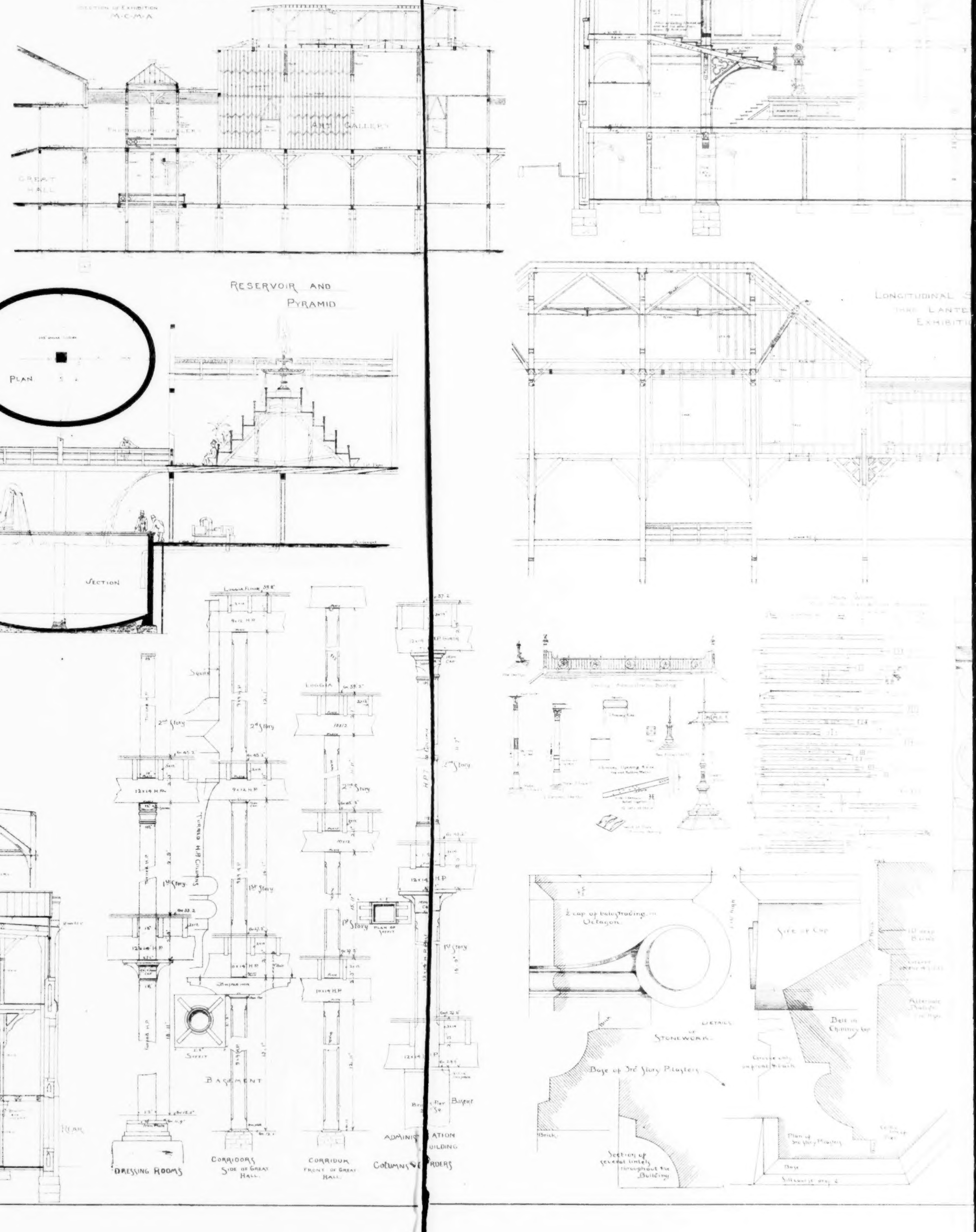


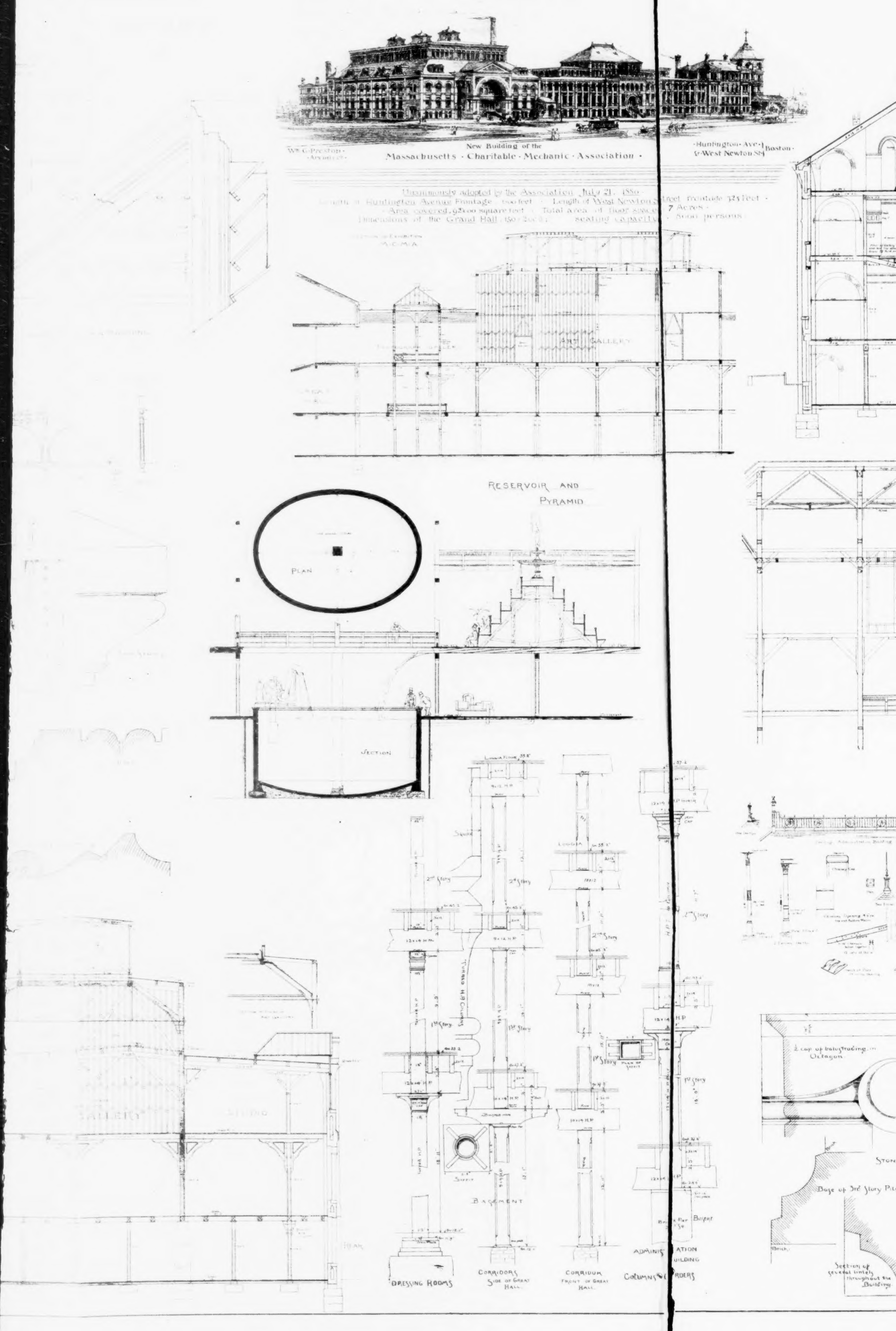
Wm. G. Preston · Architect ·

New Building of the
Massachusetts · Charitable · Mechanic · Association ·

· Huntington · Ave · & West Newton St. Boston ·

Unanimously adopted by the Association July 21, 1880 ·
Length of Huntington Avenue Frontage, 600 feet · Length of West Newton Street frontage 325 feet ·
· Area covered, 92600 square feet · Total area of floor space 7 Acres ·
Dimensions of the Grand Hall, 150×200 ft. seating capacity · 8000 persons ·

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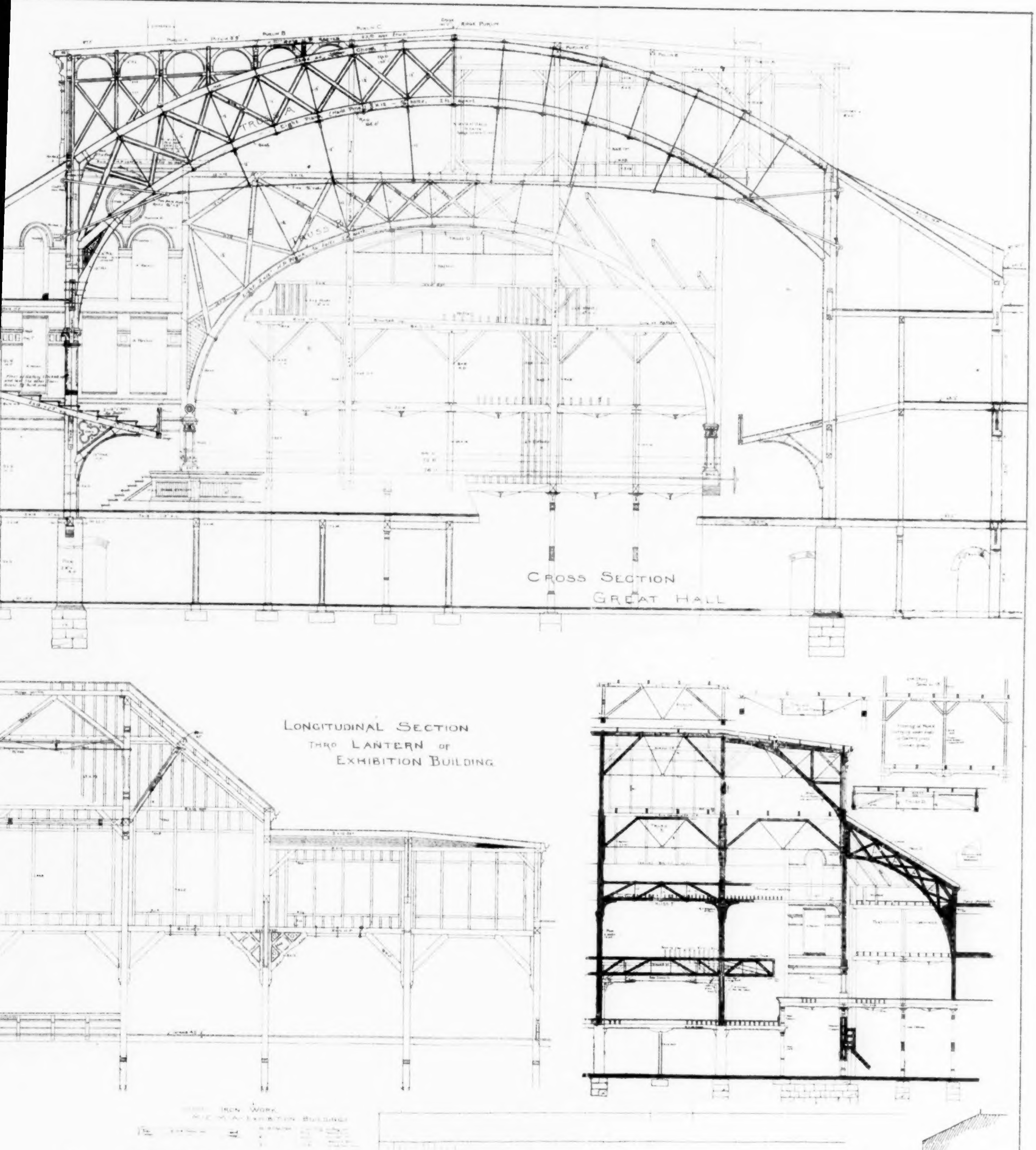
A.C.M.A.
ART GALLERY
RESERVOIR AND PYRAMID
PLAN
SECTION
BASEMENT
DRESSING ROOMS
CORRIDORS SIDE OF GREAT HALL
CORRIDOR FRONT OF GREAT HALL
COLUMNS & GIRDERS
ADMINISTRATION BUILDING
2nd Story
1st Story
Loggia
Cap of balustrading in Octagon
Base of 3rd Story Pi
Section of several lintels throughout the Building
STON


Cross Section
Great Hall
Longitudinal Section
thro Lantern of
Exhibition Building
Side of Cap
Belt in Chimney Cap
Details of Stonework
Pilasters
Sketches of Terra-Cotta
Pediment "Great Hall" Bldg
Details of the New Building of the Mass. Charitable Mechanic Association.
Wm G. Preston Architect. Boston.

stream of water run down into the rooms below (Fig. 57), and this can only be prevented by cutting the groove quite deep, an inch or so, instead of the half-inch, which is common, turning in the flashing to the very bottom of the groove, and wedging it firmly in with slate chips and cement. The wooden chips generally used for the purpose soon shrink and become loose.

Hips are covered with strips by putting a wooden "hip roll" on the boarding and laying the slates close up to it, subsequently tacking on the metal, fitting it closely around the roll, and letting it extend on each side three or four inches over the slates (Fig 58).

The essence of the rival method consists in its employment of small pieces of metal lapped over each other, without soldered joints, so that they can expand and contract freely.

Flashing with Small Pieces.

In forming valleys by this mode a sufficient number of trapezoidal pieces of zinc or other metal are cut out (Fig. 59), in length equal to one of the slates used, and in width varying from about ten inches at one end to fifteen or more at the other, according to the pitch of the roof. These pieces are taken on the roof by the slater and "slated in," each forming a part of the two courses of slate corresponding on each side of the angle (Fig. 60), and each being laid over the course of slates next below it, while the slates themselves are laid more closely into the angle of the valley than when the other system is employed. Although more metal is used in this way, the labor is less, and the work on the whole more satisfactory, because more permanent.

Fig. 59.

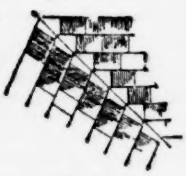


Fig. 60.

In its application to the flashing of walls and chimneys there is less to be said in favor of it, compared with a first-class job in the other style. In the "stepped flashing," as it is called, composed of small pieces, no groove is cut in the masonry, but short lengths of the horizontal mortar joints are raked out, and pieces of metal are cemented in, one above another, lapping over each other like a flight of steps.

Stepped Flashing.

This is much more permanent than a single strip, especially if the pieces, instead of being inserted in a raked-out joint, are built into the masonry itself, as is often done; but in exposed situations the wind and rain are likely to blow into the vertical crevices which are left between the masonry and the metal when this is folded down against it, so that elastic cement, or a stopping of "paint skins" and fine sand are necessary to make them tight.

The principle of subdivided flashings is applied to hips by slating in pieces of metal, the slates then being laid out to the very edge. This is both tighter and neater in appearance than the hip roll with its spreading sides.

After a discussion with the roofer on all these points, we decide that the hips and valleys shall have flashings slated in, but that ordinary flashings in long strips shall be used where the roof comes against masonry. The stone-work is in places so rough that it would be impossible to turn down a sheet of stepped flashing against it so closely as to be tight, and the other mode seems preferable, but we enjoin upon the roofer the greatest care in securing the strips into the grooves.

As for the metal of the flashings, we insist that those on walls and chimneys shall be "capped," and that the capping shall be of four-pound lead. All the rest we direct to be of No. 13 (sixteen-ounce) zinc.

Capped Flashings.

The contractor demurs somewhat to capping the long flashings, but the superintendent persists, and the roofer, on being closely questioned, finally acknowledges that they cannot in any other way be made reasonably permanent, and as the contract requires that the tightness of the roof shall be guaranteed for two years, he at length, influenced by the instinct of self-protection, yields.

This capping is the best safeguard against the evil effects of expansion on long flashings, and consists in making them in a certain sense double; one strip of zinc covering the roof, and being turned up against the masonry, almost to the line of the "raggle," or groove, with a few nails to keep it in place, while a second strip of lead, thin enough to be easily dressed close against the wall, is cemented into the "raggle" just above the upper edge of the zinc strip, and turned down over it, reaching to a line an inch above the surface of the roof, so that the two pieces of metal can expand and contract independently without in time opening a joint. It must not approach nearer than an inch; if it does, it may dip into a current of water or melted snow flowing down the roof, and the capillary attraction between the two metal surfaces will draw moisture up, and over the edge of the inner strip, to find its way into the rooms below.

The mason, who is all ready to cut the reglets, asks us whether he shall make those on the rear of the copings by raking out the joint between them and the masonry below, or shall cut them in the coping itself. There is some advantage in protecting the bed of the coping, so, although we are sorry that we did not think in time to have the leaden strips laid into the mortar before setting the coping, which would have made an admirable arrangement, we order the grooves to be cut two inches above the bed joint of the coping; to be at least one inch deep, and Rosendale cement to be provided, ready mixed, for setting the lead into its place.

LEGAL NOTES AND CASES.

Building Contract. — Failure to Complete Houses. — Damages against Builder. — Cost to Complete. — Taxes, Interest and Insurance.

THE measure of damages against a builder for a failure to complete the construction of houses which he had contracted to build, and to finish within a certain time, was considered by the New York Court of Appeals, in January, in the case of *Kidd vs. McCormick.* McCormick undertook to build four houses, and to complete by the first day of the following September, but he abandoned the buildings before they were finished, and Kidd, the owner, took possession, and carried the work through. The opinion of the court was delivered by Folger, C. J., who said: "Clearly he is entitled to have from him as much as will put him in as good plight as he would have been had the houses been finished. *Larraway vs. Parkins,* 10 N. Y., 371; *Merrill vs. Ins. Co.,* 33 Ib., 429; *Bell vs. Walker,* 5 Jones (Law), 43; *Vivian vs. Champion,* 2 Ld. Raym., 1125; *Yates vs. Dunston,* 24 L. J., 226; *Smith vs. Peat.* 9 Exch., 161; *Luxmore vs. Robson,* 1 B. & Ald., 584; *Stratt vs. Farlar,* 16 M. & W., 249; *Robinson vs. Harman,* 1 Exch., 850; *Evelyn vs. Raddish,* 1 Holt, 543, and see 7 Taunt., 410; *Tracy vs. Albany Exch. Co.,* 7 N. Y., 472; *Holliday vs. Marshall,* 7 Johns., 211. I am aware that there has not been harmony in the expression of learned judges, in passing upon the question of the measure of damages. I apprehend, however, that it has been principally in pointing out the kind of testimony, by which the amount of damages was to be got at, rather than in the rule that was to govern. Stated in its broadest form, the plaintiff is to have that compensation which will leave him as well off as he would have been had the contract been fully performed. With more particularity, he has a right to a house as good as that which the defendants agreed to furnish; and his damage is the difference between the value of the house furnished and the house as it ought to have been furnished. One kind of testimony by which that difference may be made known is that of experts, saying what would have been the value of the one, and what is the value of the other. Another kind of testimony is that of experts, what would it cost to complete the unfinished house up to the mark of the contract. Another kind is, when the house had been in fact finished, up to that mark, what it did in fact cost to finish it. But these ways all lead to the same end: what is the difference in value between the unfinished house and a house had it been finished as agreed upon. And this is to be observed of the last-named kind of testimony, first, that the plaintiff is not under obligation to go on and finish the house; second, that he cannot always finish it, as he could not in the case in hand, at the day called for by the contract; when there will come into the damages the element spoken of by Marvin, J., in 33 N. Y. *supra,* of loss from delays; and third, that the cost of actual building may have increased after the day of performance, and so be a detrimental gauge of damage for the defaulting contractor.

"The plaintiff was entitled, on the first of September, 1877, that there should be finished houses, rentable, and so productive of income, with which to keep down interest on the mortgages on the lots, the taxes thereon, and insurance premiums. He could not on that day, had he been let into immediate possession and control, by any expenditure of money or energy, have completed them at once; nor, in the nature of things, could he have supplied the lack of the completed houses by a purchase in the market. The work needed to complete was one of time; and while the time was running, interest was running also, taxes were levied, insurance was to be kept up, and the premises were yielding no rent. It is plain, that to repay him just what he expended to finish the buildings would not make him whole; for he had to pay, besides the cost of building, interest to Grannis, and lose interest on his own mortgages, and pay taxes and premiums. To put him in as good predicament as he would have been had the buildings been done on the first of September, 1877, he should have the difference in value between the buildings thrown on his hands unfinished, and the houses as they would have been if completed according to the contract. This seems to us the rule that will give him full compensation." H. E.

Negligence. — Master and Servant. — Independent Business of Contractor.

A slater, who carried on an independent business, had a contract to roof a church, and a ladder which was in use by his workmen fell, whilst they were on the roof, and injured a passer-by. By the contract with the slater he received four dollars a day for each workman, and he paid them one dollar and a half each. The injured person sued the church corporation for the negligence of the workmen, upon the ground that they were the employees of the church, and he recovered a judgment. Upon appeal in this case, *McCarthy vs. Second Parish of Portland,* the Supreme Judicial Court of Maine reversed the judgment. Judge Walton in the opinion said: "The question is whether the parish is responsible for the injury. We think not. True, the law makes a master responsible for the negligence of his servant, but the employment of one who carries on an independent business, and in doing his work does not act under the direction and control of his employer, but determines for himself in what manner it shall be carried on, does not create the relation of master and servant, and this responsibility does not attach. The general rule, says Judge Thomas, in *Linton vs. Smith,* 8 Gray, 147, is that, he who does the injury must respond; that the well-known exception is that the master shall be responsible for the doings of the servant whom he selects, and through whom, in legal contemplation, he acts; but when the person employed is in the exercise of a distinct and independent employment, and not under the immediate supervision and control of the employer, the relation of master and servant does not exist, and the liability of a master for a servant does not attach. And see *DeForrest vs. Wright*, 2 Mich., 368; *Moore vs. Sanborne*, 2 Ib., 519; Shearman & Redfield on Neg. §§ 76, 77; *Milligan vs. Wedge*, 12 Ad. & E., 177; *Murray vs. Currie*, L. R., 6, C. P., 24; *Reedie vs. R. R. Co.*, 4 Exch., 244; *Murphey vs. Caralli*, 3 H. & C., 461; *Pearson vs. Cox*, L. R. 2, C. P. Div., 369; *Forsyth vs. Hooper*, 11 *Allen*, 419; *Wood vs. Cobb*, 13 Ib., 58; *Eaton vs. R. R. Co.*, 59 Me., 520.

"Here we have a case where a man who is carrying on an independent business is employed, in the regular course of his business, to do a job of work; he is left entirely free to do the work as he pleases; he sets two of his own servants at work upon the job, charging his employer a much larger sum for their labor than he pays them; they so negligently place a ladder in use by them that it is blown down by the wind, and injures a passer-by. Now, if it be a rule of law that one who carries on an independent business, and, in doing jobs of work for others, acts independently, so far as the manner of doing it is concerned, is a contractor, and not the servant of his employer, can there be a plainer case for the application of the rule than this? We think not." H. E.

Fixtures. — Show-Cases.

Two show-cases were claimed as fixtures. The base was three feet high, and was in drawers; above this were rows of shelves to the height of seven feet, and they were inclosed by doors; and mirrors, four feet by seven feet, placed in recesses, formed part of the cases; a cornice ran along the top, and there was heavy moulding at the bottom. The cases were respectively thirty feet and thirty-nine feet in length, and the upper part of each of them was secured by rails to the wall. *Held*, That it is evident that these cases were not fixtures, but were the furniture of the tenants. *Kimball vs. The Grand Lodge of Masons*, Supreme Judicial Court of Massachusetts, April, 1881. H. E.

THE IMPURITIES IN WATER.[1]

I will now pass on to a consideration of some of the impurities contained in natural waters, — in water as it is supplied to us for use in every-day life, — explaining, where that is possible, the sources and method of contamination, and further, discussing the chief precautions necessary for the removal of such impurities as are prejudicial to the domestic utility of this valuable agent. First, then, we will consider the gas found in solution in natural waters. With some trifling exceptions, viz., some of the rarer mineral waters, the gases dissolved in water are those which are present in our atmosphere, — oxygen, nitrogen, carbonic acid, and ammonia. The oxygen and nitrogen gases, the elementary constituents of the atmosphere, are present in it in invariable quantities, and are far less soluble than the other two.

The carbonic acid and ammonia, or compound gases, are chiefly products of animal life, and are constantly being removed by plants and vegetable organisms, but they are also more soluble in water than the first two. The carbonic acid is present in larger proportion than the ammonia, whilst it is also far less soluble than the latter gas. Indeed, after a long-continued fall of rain, the presence of ammonia in the air of a place is hardly recognizable.

Spring-waters are very apt to contain much larger quantities of CO_2 than rain-water or river-water. Meandering, as they frequently do, through subterranean passages, they are exposed in their course to influences peculiarly favorable to their conversion into strong solutions of this gas. The earth being the common receptacle for dead organic matter, and her cavities being in many cases never penetrated by the sun's rays, or ventilated in any way, accumulations of carbonic acid are to be expected in these regions. The water, then, which is often very cold (it may be produced by melted snows), is churned up at frequent intervals along its course with these terrestrial gases, and becomes, in consequence, highly charged with them.

We are able to demonstrate the presence of dissolved gases in water, by simply boiling it in an apparatus, and collecting the permanent gas which escapes, as is being done here. The presence of these dissolved gases in water appears to be in every way beneficial. If we consider water as a beverage, the sparkling and refreshing effect of spring-water is largely due to the dissolved gas, especially to the carbonic acid gas which it contains. Again, boiled or distilled water, from which the gases have been expelled by heat, is mawkish and insipid, but may be again rendered palatable by aërating it with charcoal. But more than this, absolutely gas-free water (which, however, can only be obtained by boiling water *in vacuo*) boils at a temperature considerably above 100° C., and with violent explosion.

Again, it is probable that the oxygen dissolved in water oxidizes, and removes some of the more readily putrescible organic matters contained therein; and it certainly is of the utmost importance to the life of fish. The dissolved gases in water also exert an important influence upon its solvent action for solids, as we shall now find. The solid substances dissolved in waters are generally chlorides, sulphates, and carbonates of the alkalies, and of the alkaline earth metals.

[1] Portions of a paper by George Stillingfleet Johnson, M. R. C. S., F. C. S., read before the Society of Arts, April 28, 1881.

Those waters which contain the alkaline earths in solution are divided into (1) calcareous and (2) magnesian waters, the former containing sulphate or carbonate of lime in solution, the latter sulphate or carbonate of magnesia. Such waters are said to be hard. Now, it is in the case of the carbonated calcareous and magnesian waters that we observe most distinctly the influence which a dissolved gas may exert in modifying the solubility of a solid in their common solvent. For the carbonates of lime and magnesia are insoluble in pure water or nearly so; but considerable quantities of these salts may be brought into solution by water charged with carbonic acid gas. For instance, if I bubble carbonic acid gas through this clear lime-water, we first observe a milkiness, due to formation of the insoluble carbonate of lime; and on continuing to pass the gas, we finally obtain a clear solution. The dissolved gas enables the water to overcome the molecular sluggishness of the calcic carbonate, and to reduce it to the liquid condition. Now if I boil this clear solution of bicarbonate of lime, the excess of gas is expelled by the heat, and the water, no longer aided by the mobile carbonic acid gas, loses its power of keeping the calcic carbonate in the liquid state; accordingly that salt is reprecipitated.

Bearing the facts in mind, we shall be able to explain some of the phenomena of nature in connection with this subject of calcareous waters. We have seen that spring-waters are frequently highly charged with carbonic acid gas; now carbonate of lime, in the shape of chalk deposits and limestones of various kinds, is a very constant ingredient of the soil in many parts of the earth's surface. It must, therefore, be a matter of very frequent occurrence for water, already highly charged with carbonic acid gas, to come in contact with carbonate of lime in the course of its subterranean wanderings; hence the frequent contamination of natural waters with dissolved carbonate of lime. But there is another interesting and very beautiful phenomenon which we are enabled to explain by the light of the above facts. I mean the formation of stalactites. Suppose a water holding in solution much carbonate of lime and carbonic acid gas to trickle slowly through the roof of a cave. From each drop of water, as soon as it finds itself exposed to the common air, some of its dissolved carbonic acid gas will begin to evaporate, and for each molecule of gas which thus leaves the water, a molecule of calcic carbonate will be deposited in the solid form. Let a few of these solid particles adhere to the roof of the cavern, and from the nucleus thus formed, the production of vast conical masses, with their beautiful tapering apices pointing towards the earth, is only a matter of time. The nature and quantity of the dissolved salts in spring-water will, of course, vary with the composition of the soil through which it has passed. Many mineral waters are of great medicinal value.

We will next consider the influence of dissolved lime-salts upon the domestic utility of water. Is "hardness" in water prejudicial? If we consider the water as a beverage, the answer would be, No. The worst that hard waters have been accused of is that they produce a tendency to calculous formations in those who drink them. But I think the water-drinker may answer to that charge, "Not proven." And, on the other hand, we cannot but remember that the metals calcium and magnesium, in combination with phosphoric and carbonic acids, play the important part of conferring the requisite degree of hardness and stability to our frame — are, in fact, the earthy constituents of the skeleton. But there is another purpose for which water is employed, viz., for washing, and which is hardly less important than that we have just considered. For this purpose hard water is certainly disadvantageous.

Soap contains fatty acids, which form insoluble compounds with the lime and magnesia in hard waters, and no lather will be produced till all the lime and magnesia dissolved in the water have been precipitated in this way. And this occasions a waste of soap.

Now, what is called the temporary hardness in water may be removed by boiling it. The expulsion of the dissolved carbonic acid gas by that means leads to the removal of the calcic carbonate from solution in the water, and the hardness due to that cause is then removed. But the water may contain sulphate of lime in solution, which will not be removed by boiling the water. On the contrary, unless the water had been previously saturated with the salt, the evolution of steam in boiling would rather tend to concentrate its solution, and thus the permanent hardness due to this cause would remain. Moreover, there is a further objection to boiling water (except in small quantities) for the purpose of removing its hardness, since, besides the consumption of fuel which is necessarily incurred, the deposited calcic carbonate tends to form boiler incrustations, often of considerable thickness, upon the walls of the vessel employed for the purpose, and if they do not lead, as they have too often done, to dangerous accidents by their suddenly becomed detached, and producing explosive bursts of steam, by allowing the water to come in contact with the strongly heated metal wall of the vessel, yet must invariably cause great waste of fuel, owing to their inferiority as conductors of heat. Therefore, the process of Mr. Clark, which is conducted without any application of heat at all, was a great boon to mankind, especially as it has the additional advantage of clarifying a water as effectually as any filter.

The problem before us is essentially this: How may dissolved calcic (and magnesic) carbonate be best removed from solution in water? *i. e.*, How may these salts be converted into suspended and insoluble matter with the smallest possible expenditure of time and money? We have seen that the method of boiling the water, though effectual, is objectionable on the score of expense, liabilty to accidents, etc. Now, in Mr. Clark's process, which I have said is preferable, the suspended insoluble calcic carbonate produced has to be removed by subsidence. There are two methods by which suspended matter is removed from water in nature, — subsidence and filtration, and these processes are also adopted by man for the same purpose. Now, it is claimed for the method of purification by filtration that organic matters are oxidized by the substances employed, *e. g.*, charcoal, which has the property of retaining oxygen gas in its pores. But the process of Mr. Clark also undoubtedly removes dissolved organic matters from waters, the lime which is added acting as a mordant, and producing their precipitation. Mr. Clark's process is as follows: — By adding quick-lime or hydrated (slaked) lime to a carbonated calcareous water, the carbonic acid gas, which is holding the carbonate of lime in solution, is first removed by combination with the added lime, and the carbonate of lime thus produced falls, together with that previously in solution, as a solid insoluble precipitate. The turbid water is left to clear by subsidence, and is afterwards drawn off freed from temporary hardness.

I have hitherto been speaking of what may be called unavoidable impurities in water, — impurities, viz., which are introduced by natural processes which are beyond the control of man; but before concluding, I must allude, however briefly, to a very important accidental source of contamination of water, which is sometimes introduced by man himself: I mean the contamination of water with lead. And here we shall find that the influence of dissolved matters in any water is extremely important in modifying its solvent action upon this metal. Lead, from the ease with which it is worked, and the resistance which it offers to atmospheric action, changes of temperature, etc., has been found to be a very convenient metal wherewith to construct pipes for conveyance of water, and cisterns for its storage. But lead is dissolved in appreciable quantities by some natural waters, and the long-continued ingestion of that metal, even in very minute quantities, produces serious symptoms of disease in the human subject, so much so that the metal has given its name to at least two specific affections, lead colic and lead palsy. It becomes, then, a matter of the utmost importance to be able to state, from a knowledge of the ingredients of any given water, whether or not it will be safe for persons to drink that water after it has been stored in leaden cisterns, — whether or not that particular water is likely to exert any solvent action upon the metal. This we are able, in many cases, to do. For it has been found that pure water, free from both dissolved solids and gases, has no solvent action upon lead. But water containing dissolved oxygen becomes impregnated with lead, oxide of lead being, to a certain extent, soluble in water.

1. Practical Deduction: — Rain-water, stored in lead, must not be used for drinking purposes. Again, when waters containing carbonates, and especially sulphates, in solution are stored in leaden cisterns, the metal becomes coated with an insoluble protecting film of carbonate and sulphate of lead, further action being thereby prevented, and the water does not become saturnine.

2. Practical Deduction: — Carbonated and sulphated calcareous waters may usually be stored in lead with impunity. The film which forms on the surface of the metal should by no means be removed.

3. Waters containing nitrates and chlorides in abundance cannot safely be stored in leaden cisterns, since the nitrate and chloride of lead are soluble salts. The practical deduction from this is obvious.

In concluding, I hope I have convinced most of my hearers that, though we do not drink pure water, it would be very much worse for us if we did, and that, whilst we may sometimes be inclined to ask, "Why is such a substance here?" we generally find at last that it serves some importance purpose which had escaped our ken, — in fact, that we are finally led to wonder at the Wisdom which works through intricate and complicated labyrinths to a perfect and simple end, and are forced to admire the ultimate tendency and result of even such seeming anomalies as the "impurities in water."

THE ILLUSTRATIONS.

DETAILS OF THE MASSACHUSETTS CHARITABLE MECHANIC ASSOCIATION'S BUILDING, BOSTON, MASS. MR. W. G. PRESTON, ARCHITECT, BOSTON, MASS.

THREE great buildings, separated by brick walls and fire-proof doors, form the exhibition building, which has a frontage of 598 feet on Huntington Avenue, and of about 317 on West Newton and Gloucester Streets. These two sides are those of a right-angled triangle, the hypothenuse being the northerly side, bordering upon the Boston & Albany Railroad yards, a 15-foot passageway being reserved for light and air. The building will be of red brick, laid in dark mortar, with slated roofs and lanterns, and dormers of iron. The walls are to be built vaulted, and not less than two feet thick, while some portions will be four and five feet in thickness, thus giving great depth of window opening and projection of piers. The "administration building" at the easterly end, nearest to Dartmouth Street, contains the grand entrance and staircase halls, in an octagonal tower, about 38 feet diameter, and 90 feet high, entirely of masonry, and devoted to that purpose. This administration building has a basement and three stories above it. The first is devoted to committee rooms, etc. The second story contains the restaurant, having an area of about 3,000 square feet, and several smaller rooms, while the third story will contain the Association Hall, about 43 x 85, which will seat some 700 persons. The main staircase in the brick tower is seven feet wide. Another of four and one-half feet is at the rear of the hall, and an iron staircase outside leads to the ground at the rear. The kitchen and dependencies are on this floor, with lantern and top ventilation. The walls will be plastered directly on the brick, with no spaces for fire to run up between. Plastering will be laid between the floors, the staircase wire-lathed and filled solid with plaster under the steps, to avert all danger of fire in that direction. The "exhibition hall" is 150 x 270 feet, and has a basement of 15 feet in height, well lighted on both sides and by well-openings in the floor above, and is to be used for heavy machinery. The first story will be 18 feet, and the second, or gallery, 15 feet. A clerestory lights the central portion of this hall.

In close connection with the elevator and staircase on the second floor is the art gallery, a room 50 x 90, having a hanging height of walls of 24 and 31 feet to the glass ceiling light. Adjoining this room is another, about 45 x 72 feet, and 19 feet high, with top lights, to be used for the display of photographs. Six studios, averaging 22 x 30 feet, line the northern wall, and have both side and sky light, chimneys, ventilators, etc.

The great chimney, 11 feet square, 110 feet high, is built in this section of the building. It is to be so constructed that the waste heat from the boilers will be used in enforcing ventilation at various points. The boiler-room, arranged for four boilers, is at the base of the chimney, and adjoining are solid granite foundations for the engines used for furnishing power for the exhibitions, and as a firm basis for the competitive trials of engines running at high speed.

The floors and roof of this section of the building, as also the roof of the "great hall," are to be of what is termed "mill construction," *i. e.*, the floor timbers are to be made very heavy, of hard pine, and placed six feet apart. The flooring is to be three inches thick, the whole planed and beaded so as to make a finished ceiling beneath and floor above.

In the basement is a doorway of ample width for cars to be run directly into the building from the Boston & Albany Railroad, and overhead an iron crane for unloading goods.

From the exhibition hall, on the three stories, open 27 wide doorways into the "great hall" section. As in the other parts of the building, a basement, 15 feet in height, extends under its whole area. The entrance to the hall from Huntington Avenue is beneath an arch of 34 feet span. A flight of granite steps, 35 feet in width, leads up to a large vestibule, containing ticket offices and opening into corridors, 12 to 15 feet wide, which surround the hall on three sides. The audience-room is 140 x 130 feet, beside the stage recess, 84 x 30.

The great hall is surrounded on three sides with two galleries: one, the lower, sloping, and to be seated; the upper, or *loggia*, will be level, and to be used mainly for exhibition and kindred purposes. The roof is spanned by five great arched girders, of hard pine, and 118 feet span. The hall is lighted by a clerestory, with windows 16 feet in height on all its four sides. Three iron ventilating turrets are built upon the upper roof-deck, which are 18 feet in diameter. The exit doors from the great hall aggregate 150 feet in width, — nearly two feet to each 100 of the audience. It has a seating capacity of 3000.

Directly in the rear of the great hall, in the basement, first and second stories, are about twenty chorus, dressing, toilet and other rooms, 30 feet square and less. This department has its separate exits and entrances. In addition to this there is in the basement a hall about 55 x 80, and 20 feet high, seating about 750 persons, which will be very useful for chorus rehearsals. This hall has a fine north light, with two special entrances from without, and several side rooms, and will be ventilated by the great chimney.

Under the exhibition hall, and extending down to "hard-pan," will be a great brick cistern, 25 x 35 feet, and 20 feet deep, having a capacity of nearly 100,000 gallons, from which the water for the fountains, cataracts, etc., will be pumped, and from which also the general supply for toilet purposes in the building will be drawn. It will be supplied mainly from the rainfall on the two acres of roof.

The contractors for the stone and brick work are Messrs. Augustus Lothrop and William M. Rumery. The sub-committee in charge of the building is Joseph F. Paul, Nathaniel Cummings, Jonas Fitch, Alonzo W. Folsom, George F. Shepard, Charles W. Slack and Nathaniel J. Bradlee.

EXPERIMENTS ON THE STRENGTH AND STIFFNESS OF SMALL SPRUCE BEAMS.[1]

THE object of the following experiments was to determine the moduli of elasticity and rupture in small beams of white spruce (*Abies alba*), and such other information as might be derived from the data obtained.

The machine used for the purpose consists of two solid wooden frames, carefully levelled and placed forty inches apart. Upon the top of each frame is placed a movable plate of iron, which is care-

[1] A paper by F. E. Kidder, printed in the Proceedings of the American Academy of Arts and Sciences.

fully adjusted so that the two plates shall be directly opposite each other, and exactly forty inches apart between the faces. These plates form the supports for the beams.

The loads were applied by means of a scale pan suspended from a three-quarter-inch bolt, which rested upon the centre of the beam. By means of an iron strap suspended from a horizontal beam placed above the test piece, and resting on two screws, the bolt from which the load was suspended could be raised from or lowered upon the test piece as easily and gradually as could be desired.

The deflections of the beams were measured by means of a micrometer screw, reading to one ten-thousandth of an inch. As the bolt from which the load was suspended rested on the centre of the beam, it was necessary to measure the deflections at a distance of one inch from the centre; but the deflections used in calculating the values of the modulus of elasticity were corrected so as to give the deflection at the centre, supposing the curve assumed by the beam to be the arc of a circle; from which, in fact, it deviates but little under such small loads. In reading the micrometer, the principle of electrical contact was taken advantage of.

The greatest errors liable to occur in using the machine are as follows:—

In measuring the deflections, one ten-thousandth of an inch. In the breaking load, possibly one pound; but in the small loads there could be no appreciable error. In measuring the dimensions of the test pieces, two thousandths of an inch.

The experiments were conducted with the utmost care, and every possible precaution was taken to prevent errors.

In arranging for the experiments, and while making them, the writer was greatly assisted by Mr. Holman, of the Institute, to whom he extends his acknowledgments.

The pieces of wood experimented on were sawn from a spruce plank that had been cut in eastern Maine in the spring of 1880, and the following summer shipped to Boston, where it had lain in the open air until it was cut up in October. The pieces were carefully planed to an approximate size of one and a half inches square and four feet long.

They were nearly all straight-grained and had but few defects, and in testing the beams they were placed so that the defects should have the least possible effect upon the strength of the beams. The exact dimensions of the test pieces are given in Table I.

TABLE I.

No. of Test Piece.	Clear Span. l.	Breadth. B.	Depth. D.	E.	E_1.	R.	Centre breaking weight for beam. 1″×1″×1′.
	ins.	ins.	ins.	lbs.	lbs.	lbs.	lbs.
1	40	1.475	1.450	1,731,000	1,657,000	11,380	632
2	"	1.445	1.520	1,536,000	1,528,000	10,330	574
3	"	1.469	1.448	1,765,000	1,732,000	10,710	595
4	"	1.420	1.498	1,736,000	1,636,000	10,830	601
5	"	1.450	1.485	1,688,000	1,578,000	11,980	665
6	"	1.480	1.440	1,795,000	1,686,000	11,040	613
7	"	1.464	1.460	1,682,000	1,561,000	10,570	587
8	"	1.420	1.480	1,647,000	1,556,000	11,280	626
9	"	1.460	1.460	1,704,000	1,638,000	11,180	621
10	"	1.441	1.460	1,616,000	1,550,000	12,440	691

In making the experiments, each beam was first subjected to a load of thirty pounds, and the deflection noted. The weight was then left on the beam for a period of time varying from one to four, and in one case forty-four hours, and the deflection again noted. The load was then removed from the beam and the set noted, after which the beam was allowed a certain time to recover from the set.

After the piece had returned, or at least nearly returned, to its original position, it was subjected to a load of forty pounds in the same manner.

Table II gives the deflection of each piece under the loads of thirty and forty pounds, both immediately after the weight was applied and after it had rested upon the beam the length of time designated.

TABLE II.

No. of Test Piece.	Weight W.	Time applied h.	Time applied m.	Deflection Δ	E.	Weight W.	Time applied h.	Time applied m.	Deflection Δ	E.
	lbs.	h.	m.	ins.	lbs.	lbs.	h.	m.	ins.	lbs.
1	30	0	00	0.0610	1,744,000	40	0	00	0.0826	1,719,000
"	"	2	25	.0630	1,689,000	"	3	30	.0873	1,627,000
2	30	0	00	.0616	1,536,000	40	0	00	.0801	1,576,000
"	"	1	45	.0639	1,481,000	"	3	00	.0842	1,499,000
3	30	0	00	.0606	1,774,000	40	0	00	.0815	1,757,000
"	"	1	00	.0610	1,759,000	"	1	00	.0840	1,705,000
4	30	0	00	.0582	1,725,000	40	0	00	.0765	1,748,000
"	"	2	25	.0616	1,627,000	"	3	20	.0813	1,645,000
5	30	0	00	.0580	1,740,000	40	0	00	.0774	1,637,000
"	"	2	30	.0618	1,630,000	"	44	15	.0874	1,527,000
6	30	0	00	.0605	1,792,000	40	0	00	.0803	1,799,000
"	"	3	00	.0639	1,697,000	"	5	12	.0862	1,676,000
7	30	0	00	.0624	1,683,000	40	0	00	.0833	1,682,000
"	"	3	00	.0663	1,584,000	"	16	00	.0911	1,538,000
8	30	0	00	.0632	1,645,000	40	0	00	.0839	1,650,000
"	"	4	15	.0666	1,561,000	"	16	30	.0894	1,552,000
9	30	0	00	.0619	1,701,000	40	0	00	.0823	1,707,000
"	"	1	30	.0643	1,638,000	—	—	—	—	—
10	30	0	00	.0661	1,614,000	40	0	00	.0881	1,618,000
"	"	2	00	.0691	1,544,000	"	1	15	.0915	1,556,000

The values of the modulus of elasticity calculated from these deflections are also given. The moduli of elasticity obtained from the deflection of the beams immediately after the weight was applied have been denoted by E, and those obtained from the deflection of the pieces after the weight had been applied one or more hours, by E_1. Table I gives the value of E and E_1 for each piece, obtained by taking the average of the values given in Table II.

The values of E were computed by the formula $E = \frac{Wl^3}{4 \Delta B D^3}$, in which W denotes the weight in pounds producing the deflection; l the clear span in inches; Δ the deflection of the beam at the centre; B, the breadth of the beam, and D the depth, both in inches.

After all of the beams had been treated in this way, piece No. 3 was again put in the machine and subjected to a load of 100 lbs., which was allowed to remain upon the beam for about two hours, the deflection being measured directly after the weight was applied and just before it was removed. The beam was then allowed a certain time to recover its set. In two cases, the beams, after having been subjected to a load of 100 lbs., finally returned to their original position, and it appeared probable that all would have done so had sufficient time been allowed for the purpose.

After the piece had nearly recovered from the effects of the load of 100 lbs., a load of 150 lbs. was put upon the beam, and gradually increased until the breaking point was reached.

The remaining pieces were tested with a load of 100 lbs. in the same way, and then subjected to a load of 400 lbs. for one or two minutes, for the purpose of getting the deflection under that load, and immediately after subjected to the full load of 500 lbs., which was gradually increased until the piece broke. As the load approached the breaking weight, it was increased by the addition of only one or two pounds at a time, so that the breaking weight could be obtained with sufficient accuracy. In fact, the breaking weight is so much modified by the time occupied in breaking the beam, that it is difficult to ascertain exactly what it really is. For any load, over three-fourths of what is called the breaking weight would probably break the beam if applied long enough.

Table I gives the values of the modulus of rupture of each piece, computed by the formula $R = \frac{3}{2}\frac{Wl}{BD^2}$, in which R denotes the modulus of rupture; W the breaking weight of the beam, and the other letters have the same significance as in the formula for E. The load which would break a beam of the same wood, one inch square and one foot between supports, if applied at the centre, is also given in the same table. This load is one-eighteenth of the modulus of rupture.

When the weight of 400 lbs. was applied to piece No. 7, it immediately cracked at a knarl in one of the lower edges, about three-fourths of an inch from the centre of the beam. As it was thought that the beam would soon break entirely, the load of 400 lbs. was allowed to remain on the beam; but at the end of one hundred hours the deflection had only increased 0.2224 inches, and as it was evident that it would, at that rate, take a long time for the beam to break, the load was then gradually increased until the piece broke at 550 lbs., giving a modulus of rupture considerably above the average. It was noticed in this beam that the deflections under the loads above 500 lbs. were considerably greater than in the other beams under the same loads.

Piece No. 5 gave a very high breaking weight, and broke very suddenly, more like the harder kinds of wood. The fracture was very perfect, the upper half of the fibres being very evidently compressed and the lower half suddenly pulled apart, with almost no splintering. This piece had a small knot on the upper side, five inches from the centre of the beam, but it appeared to have no effect upon the strength of the beam.

Piece No. 4 broke in a rather peculiar manner. While under a load of 575 lbs., the lower fibres for about a depth of one-tenth of an inch snapped apart, and the beam gradually settled down until the next layer of fibres had apparently the same deflection as did the lower ones at the time of breaking, when they also snapped, making a layer of about the same thickness. In this way the whole lower half of the beam seemed to divide itself into layers of about one-tenth of an inch thick, and to break separately under about the same deflection, so that the beam was a long time in breaking.

Observing that under every load that had been applied the deflection kept increasing with the length of time the weight remained on the beam, piece No. 7 was subjected to a load of 275 lbs. for ninety-eight hours, during which time the deflection increased 0.079 inches. The weight was then taken off and the beam allowed to recover for twenty-four hours, when it had a set of .0446 inches. The same weight was again applied, and it was found that the deflection, obtained by taking the difference between the readings of the micrometer just before and after the weight was applied, was less than it was the first time the weight was applied, and the rate of increase of the deflection was about the same as before. The beam was thus subjected to a weight of 275 lbs. for three hundred hours in all, after which it was broken in the same manner as the others. It was expected that the effect of such a severe strain for so a long a time would diminish its strength; but, on the contrary, it appeared to increase it, as the beam gave a higher modulus of rupture than any of the others, although it did not appear to be of as good quality as many of them. The ultimate deflection of this beam greatly exceeded that in any of the others.

Table III shows the deflection of each beam under loads of 30, 40, 100, 400, 500, and 550 lbs., immediately after the load was applied, and at a distance of one inch from the centre. The small figures under each deflection show what it would be if Hooke's Law held true, taking the deflection under 30 lbs. as the starting-poir'