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CONTENTS.

IT is worth while to refer again to the interesting decision delivered in the Superior Court of Massachusetts in regard to the giving of official preferences to members of trade-unions; and, although the matter will probably be appealed to the Supreme Court, the community is indebted to the judge of the court below for a remarkably lucid and forcible statement of the principles involved. It appears that the firm of Lynch & Woodward, heating engineers, contracted with the City of Boston for putting heating and ventilating apparatus into a public bath-house. The contract contained a clause to the effect that the contractors should "give preference in employment on the work to citizens of Boston and members of the several trade-unions." Lynch & Woodward, according to the evidence, endeavored to employ union men, but were prevented from obtaining them by a conspiracy of the members of the union; and, in consequence, employed non-union men for carrying out their agreement. It is not claimed that their work was not properly done, or that their men were incompetent, or their materials unsuitable, but on January 6, 1898, the Mayor caused a letter to be sent to them, signed by the architects, but avowedly drawn up in the Mayor's office, ordering them to carry on the work with union men, and notifying them that they would not be allowed to finish the work with non-union men; and referring, for the authority under which this notice was given, to the article of the contract by which the contractors agreed to cause all materials and labor to be satisfactory to the architects, and, at their request, to dismiss any employés, and deny them further employment on the work. Two days later, a notice was sent to the contractors by the Mayor ordering them to suspend operations altogether; and when they and their men attempted to continue their work they were excluded from the building by the police. They thereupon applied to the Superior Court for an injunction, specifying the City of Boston, the Mayor, the architects, and the Superintendent of Public Buildings, as defendants, and praying that each and all of them might be restrained from hindering or interfering with them in their undertaking, on the ground of their failure to employ union workmen.

THE defendants argued that the architects had, in any case, a right, under the contract, to order the dismissal of workmen at their discretion; that the plaintiffs had violated their contract in failing to employ union men, and that one of the contracting firm had orally agreed with the Mayor to employ such men exclusively, and had broken that promise, as well as the written agreement. Moreover, the Mayor testified that he was very strongly urged by committees of labor unions to terminate the contract with Lynch & Woodward as he did, and that he was afraid of a strike unless he yielded to their importunity. In regard to these points, the Court held that the clause empowering the architect to require the dismissal of workmen, when construed in connection with the other provisions of the contract, must be interpreted as reserving to the architects the right of dismissal "only for causes or reasons which pertained to the fitness or qualifications of the workmen for the performance of their work." As to Mr. Lynch's oral agreement to employ only union men, the Court said that such promise, if made, had no validity. The main reliance of the defence was, of course, on the stipulation of the written contract, requiring preference to be given to union members; but the Court held without hesitation that, although the plaintiffs faithfully endeavored to comply with it, and were prevented from doing so through no fault of their own, the stipulation itself was illegal and void, for the reason that "There is no "authority in law for any officer of the Government, State or "Municipal, to force such a discrimination as was attempted in "this case between workmen in respect to the privilege of "labor on public work paid for by taxes levied upon all, for "no reason except that some workmen belong to a certain "party, society or class, and others do not; thus giving labor, "and the benefit of it, to one class, and denying it to another, "regardless of their rights, needs, qualifications or merits, or "the public welfare." The Court even went so far as to say, in answer to a claim that the plaintiffs, instead of applying for an injunction, should seek their remedy in an action for damages, that it was "unable to see why the City should pay the "damages for the injury done to the plaintiff in this matter, "not caused or done in or for the interests of the City"; implying, apparently, that the defendants might be held personally liable for the injury caused by their proceedings.

IT is this last part of the decision which is the most important, and which will probably occupy the largest share of the attention of the Supreme Court, if an appeal is taken. It is by no means a new thing for public officials to restrict employment on public work to members of trades-unions. In London, especially, this practice has been rampant for several years; and the idea that it is illegal, that contracts embodying it are void, and that public officers who act in accordance with it are personally liable for injury done to non-union men or others in consequence of such discrimination, is a little startling. The Massachusetts Court appears to derive the suggestion of the personal liability of officials in such cases from the fact that no advantage to the City was shown or alleged to be expected from the stipulated exclusion of non-union citizens from employment. It is only fair to the Mayor to say that his action in favoring union men for city contracts is believed to be due to an impression on his part that union men might be expected to do the best work; and if his preference was embodied in the public contracts in the expectation of improving the workmanship of the city buildings in that way, he could not be held personally liable for the consequences of an honest, although unfounded, prejudice of the sort; but nothing of the kind was alleged by the defence, and, according to the theory of the Court, it would be necessary to prove some real advantage to the public to legalize such discrimination hereafter in Massachusetts.

THE *Engineering Record* has started an interesting discussion about the way in which graduates of technical schools and engineering colleges can be supplied, in addition to technical knowledge, with such command of their own language as will enable them to maintain a social position suited to their importance in the community, and to prevent their skill from being discredited by the lack of the simplest accomplishments. Every one who has taught professional students knows how urgent is the need of preparing them for a successful career by something more attractive to the persons from whom they will seek employment than a mere familiarity with the strength of materials and the properties of the catenary; yet the problem of supplying them with this requisite is by no means satisfactorily solved. Most of the higher technical institutions in this country, finding that the adoption of a reasonably high standard in the English branches would shut out many men otherwise well fitted for their courses, endeavor to meet the difficulty by incorporating a certain amount of English work in their curriculum; but this involves the expenditure of a large amount of time and money in teaching branches which are really foreign to the object of a technical school, and are only taught there because they are not taught where they should be — in the preparatory schools.

IT is to be remembered that students in engineering colleges are drawn, to a great extent, from new and small communities, particularly in the South and West, where schools, even if they exist, are of an inferior class; and, in consequence, if the candidates are properly prepared, in mathematics and physics, for the more strictly technical part of the work, it is felt to be an injustice to reject them on account of a want of skill in writing English, which may be, and often is, rapidly acquired by the student, as soon as he finds himself surrounded by more favorable circumstances. This alone would tend to reduce the average of English attainment in such colleges, but other causes contribute to that end. In the first place, the standard of literary culture is not very high among the instructors in many engineering schools, and their pupils are, naturally, not very solicitous to show accomplishments in that respect superior to those of their teachers, while the latter, in such cases, are quite likely to entertain a contempt for the refinements that they do not themselves possess, which communicates itself more or less to those whom they teach; and, in the second place, every class in a college of any sort seems to contain a certain number of men whom no amount of instruction or exhortation can ever induce to spell their own language correctly, or to express themselves in it with propriety. These singular persons are by no means confined to the technical schools; in fact, out of some thousands of examination papers, on technical subjects, which it has fallen to our lot to correct, the worst spelled, although not the worst in other respects, have been written, we believe, by graduates of Harvard College. According to Professor Randolph, of Virginia, who writes a very interesting letter to the *Engineering Record*, this orthographic obliquity is due to the environment of the subject, during his childhood, by persons unfamiliar with the English language, or careless in its use; and he thinks that the only remedy is to provide the pupil, in such cases, with a new set of parents and relations; but in every grammar school there are children from illiterate families whose work compares favorably with that of others with better opportunities; and it is difficult to avoid the conclusion that the art of teaching in schools the correct use of the English language still affords opportunity for development.

THE second competition for the John Stewardson Memorial Scholarship in Architecture will be held at the School of Architecture of the University of Pennsylvania, in Philadelphia, beginning on Tuesday, March 1st. The preliminary examination will occupy three days, and will be devoted to Architectural History, Construction and French or Italian, candidates being allowed to offer either language; and to Freehand Drawing. Those who receive a mark of not less than seventy-five per cent in Drawing, and sixty per cent in the other subjects, will be admitted to the final examination, beginning March 5th, when each candidate must make, at the school, a preliminary twelve-hour sketch. The completed drawings will also be made at the school, and must all be handed in by ten o'clock, P. M., on March 26th. The award is made on the result of the final examination; but, in case of doubt on the part of the jury as to the relative merits of two designs, the marks or the preliminary examinations may be referred to. Only those are eligible who have studied or practised architecture for one year in the State of Pennsylvania and who are less than thirty years of age. Graduates of any of the recognized schools of architecture, as determined by the Managing Committee, and those who have already once passed the preliminary examination for the Scholarship, or for the Travelling Scholarship in Architecture of the University of Pennsylvania, are exempt from this preliminary examination, and may enter the final examinations directly. The Scholarship is of the value of one thousand dollars, and the holder must spend a year in travel and study in Europe under the direction of the Managing Committee. Further particulars may be obtained by addressing Prof. Warren P. Laird, School of Architecture, University of Pennsylvania, Philadelphia.

THE engineers of the War Department have completed the preliminary survey for an imposing bridge, which is to cross the Potomac River from a point near the old Naval Observatory, in Washington, to the National Cemetery, at Arlington, on the Virginia side of the river. It is proposed to make this bridge an appropriate ornament to the new park, which is being made out of the neighboring "Potomac flats," and to dedicate it to the memory of Grant and Lincoln, probably arranging two towers on the bridge, to be called by the names of the two great Presidents. As the Potomac is a navigable river, it is intended to make the middle portion of the bridge an arch, ninety feet high, which will answer for the passage of most of the vessels which ascend the Potomac beyond Washington.

THE Custom-house officials have a hard time with the questions of art which are referred to them. Not long ago, an amateur in New York imported, through the house of Goupil & Co., a collection of miniatures on ivory, painted in the last century, and set, as the pretty custom was then, in lockets, rings, brooches and so on. When they arrived in New York, the Custom-house officers classed the whole collection as "jewelry," and demanded a duty of sixty per cent on the price which had been paid for them. As the owner, of course, had paid this price for the sake of the painting, and not for the setting, he claimed that his miniatures should be classified as "works of art," upon which a duty of twenty per cent only is payable. The case was heard a few days ago by the Board of General Appraisers, but decision was reserved. In another case, heard at the same time, the question turned upon the age of three Chinese vases. These were imported before the Dingley tariff went into operation, and the case was therefore under the previous tariff, which allowed "antiquities" to be imported free. It will be remembered that the Wilson tariff did not specify the period at which "antiquity" stopped, and the modern era began; but the Custom-house officers, finding that some boundary-line must be established, set it at the year 1700; and the point to be determined in regard to the Chinese vases was whether they were manufactured before that epoch or not. The only testimony offered was that of Mr. Inglis, of Collier & Co., who affirmed, as an expert, and judging from internal evidence, that they dated from the time of the Ming dynasty. This would place them many hundred years on the safe side of the dutiable line; but the General Appraisers in this case, also, reserved their decision. It may be remarked, for the benefit of people interested in the importation of antiquities, that the present tariff makes no exception in favor of antiquities over any other works of art, and that it is therefore unnecessary for them to spend time in researches, for the benefit of the Custom-house officers, into the ancient history of the countries from which such objects are brought.

MR. JOHN CASANI, an expert plaster-worker, died in Philadelphia last week. He was very well known to artists, not only for his skill in rendering the clay models of sculptors in plaster, which brought him employment from all parts of the country, but for his remarkable personal beauty, and he very often stood as a model for the local artists.

THE people of New York, taking warning, perhaps, from the confusion and injustice which have been caused by the revolution in the Boston building-laws, are trying to draw up a new statute, which the persons most interested, that is, the architects, builders and real-estate owners, shall not only have a chance to discuss before inactment, but which shall be prepared by their representatives. Whether their plan will prosper or not remains to be seen, but it is certainly desirable to have such ordinances prepared by members of the professions concerned, who alone can judge of the remote effects and relations of new building regulations, rather than by lawyers, who, even if they are not paid, by persons whose interests are not those of the public, to procure legislation of the sort, very rarely know or care how it will affect anybody except themselves or their clients. As an example of the way in which building statutes are imposed upon a community which has many thousands, and perhaps millions, of dollars staked upon their interpretation, it was mentioned the other day, at the meeting of the Joint Committee which is considering the proposed Building Code, that a bill is now pending in the New York Legislature limiting the height of buildings, apparently in total disregard of the new city charter, which expressly delegates to the Municipal Assembly the right "to regulate or restrict the height of buildings," and to amend the building-laws of the city. If the Legislature should pass the pending bill, and the Municipal Assembly should establish a limit of height different from that prescribed by the statute, it would, apparently, be necessary to suspend the approval of all plans for important structures until the courts could determine which ordinance must be obeyed, the owners, meanwhile, losing interest and taxes, probably to a very large amount.

STATICS OF STRUCTURES. — THEORETICAL AND APPLIED.[1] — IX.

THEORY OF THE ARCH.

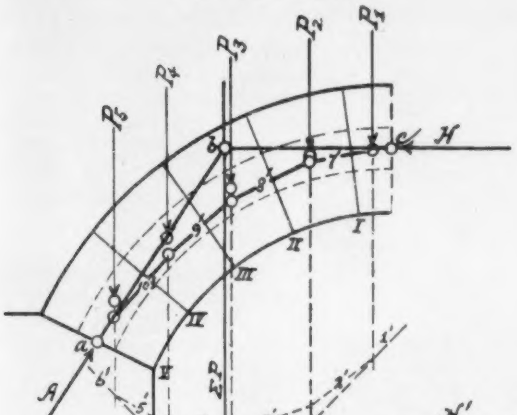

Fig. 82.

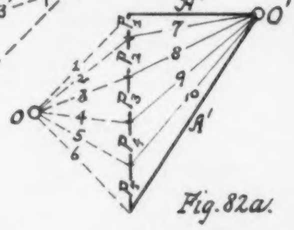

Fig. 82a.

166. The masonry arch is a structure composed of a number of wedge-shaped pieces or *voussoirs*, so arranged as to span an opening between two abutments, while sustaining its own weight and very often that of superimposed loads.

Such an arch may be *straight*, *semicircular*, *segmental*, *elliptical*, or *pointed*, according to the manner in which the voussoirs are cut and arranged. Curved arches are usually convex above, though some occur which are concave above; the latter are called *inverted* arches. The outer curve of an arch is known as the *extrados*, and the inner the *intrados*.

167. In the case of beams we found that the loads they carried gave rise to strains, resisted by stresses, the amount and direction of which could be readily ascertained. The same is true of the arch. The weight of the several voussoirs, combined with that of the superimposed load, if there be any, calls forth pressures which traverse the arch from its crown to the abutments, where they are counteracted by the reactions. If the pressures acting at the several joints are combined into resultants — one for each joint — and these in turn into a continuous line extending from voussoir to voussoir, we get what is known as the *line of pressure* of the arch. Combining the stresses which resist these pressures into a similar line of resultants gives the *line of resistance*, which coincides with the line of pressure, but is opposed to it in sense. These terms are often, however, used indiscriminately.

168. The line of pressure is constructed as follows (Figs. 82, 82*a*): —

The weights P_5, P_4, — P_1 of the several voussoirs, assumed as loads acting vertically through the centres of gravity of the voussoirs, are combined into a load-line, Figure 82*a*, a pole *O* assumed, and a cord-polygon 6′, 5′ — 1′ drawn. By means of this the resultant ΣP of the weights $P_5 — P_1$ is found according to the method described in § 57, Figure 18.

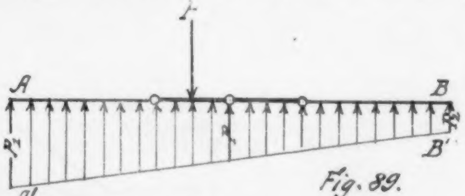

Fig. 89.

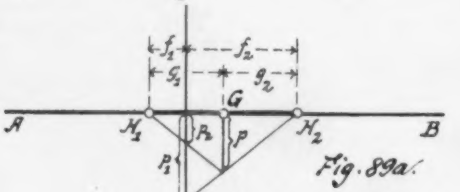

Fig. 89a.

Now, the half-arch under consideration is held in place by the thrust *H*, exerted at the crown by the other, right-hand, half-arch; and the reaction *A*, exerted by the abutment at the rising line.

The thrust *H* we shall, for the présent, assume to act at the centre *C* of the crown; its direction is horizontal, because the arch is symmetrical. The reaction *A* we similarly assume to act at the centre *a* of the impost or springing joint. The direction of *A* is determined by the requirement that it must pass through the intersection of *H* and ΣR, for, if equilibrium is to exist, these three forces must pass through one point.

Drawing *H′* and *A′*, in Figure 82*a*, parallel to *H* and *A* respectively, results in the force-triangle *H′*, $P_1 — P_5$, *A′*, from which the magnitude of *H* and *A* may be scaled.

169. Now, after assuming the intersection of *H′* and *A′* as a new pole, *O′*, we draw the rays 7, 8, 9 and 10, and parallel to them the new cord-polygon 7′, 8′, 9′ and 10′ in Figure 82; beginning with 7′ at the point of intersection of *H* with P_1, and ending with 10′ at the intersection of *A* with P_5.

Ordinarily this cord-polygon *H*, 7′, 8′, 9′, 10′, *A* is called the line of pressure and serves all practical purposes as such; but the real line is a curve, to which the cord-polygon is tangent.

The amount of the pressure at any point can evidently be found by referring to the rays 7 . . . . 10 in Figure 82*a*. The pressure on joint *I*, for instance, is equal to the resultant of *H′* and P_1, or 7; that on joint *III* to the resultant of *H′* and $P_1 + P_2 + P_3$, or 9; and so on; the horizontal component remaining constant, while the vertical component increases as the abutment is neared.

170. The stability of an arch depends on the position of its line of pressure, which must traverse it within certain limits, in order that the compression may nowhere exceed the safe stress, or, what would be still more undesirable, that no joint be subjected to tension, which masonry is practically incapable of resisting.

Before these limits can be determined, it will be necessary to insert here a few remarks about the neutral axis and other properties of cross-sections in general.

171. The neutral axis of a cross-section, as we already know, is that line at which there exists no strain or stress whatever (§ 11). It may lie within or without the cross-section; if within, the stresses on either side of it are of opposite sense, as we found in the case of the beam subjected to transverse loading, in which the upper fibres were in compression and the lower in tension; if without, the section is subjected to only one kind of strain over its entire area, as, for example, in the case of a column, pier or arch correctly proportioned.

The exact location of the neutral axis is dependent upon the position of the point of application of the resultant or resultants of the normal strains to which the cross-section is subjected. In other words, for every point of application there is a corresponding location of the neutral axis. A few examples will make this clearer.

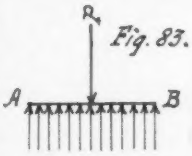

Fig. 83.

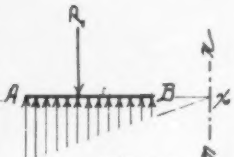

Fig. 84.

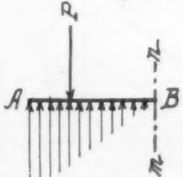

Fig. 85.

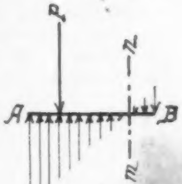

Fig. 86.

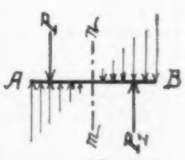

Fig. 87.

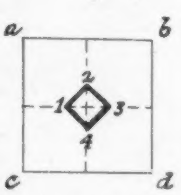

Fig. 88.

172. Thus, let *A B* (Fig. 83) be a rectangular cross-section subjected to a strain *P* applied at its centre-of-gravity. The stresses resisting *P* (indicated by the small arrows) will all act in the same direction and be of the same intensity over the entire section. But we know that the stress at any point of a section varies with its distance from the neutral axis (§ 27); if, therefore, all the stresses are of equal intensity, all parts of the cross-section must be equidistant from the neutral axis. There is only one way in which this condition can be fulfilled: the neutral axis must lie infinitely far off, which consequently is the assumption made in this case.

Now, if *P* is shifted from the centre-of-gravity towards the edge *A*, as in Figure 84, the stresses will no longer be of the same intensity throughout the entire section, but greatest at the edge *A*, of average intensity at the centre-of-gravity, and least at the edge *B*. Consequently the neutral axis *m n* no longer lies infinitely far off, but has moved up to the point *x*. If *P* is brought still farther towards *A*, the neutral axis will come still closer, until, finally, when *P* is at $\frac{1}{3}$ of the width of the cross-section from *A*, and $\frac{2}{3}$ from *B*

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[1] Continued from No. 1140, page 42.

(Fig. 85), it will just touch the cross-section, *i. e.*, pass through *B*. Now the stress is double the average at *A*, and gradually decreases towards *B*, where it is equal to zero. It is still of the same sense throughout.

Any further movement of *P* in the direction of *A*, however, will result in bringing the neutral axis into the cross-section (Fig. 86), dividing it into two parts, with stresses of opposite sense. An example of this kind, with which the reader is already familiar, is given in Figure 87; it is that of a beam transversely loaded. Here *P* is applied at two-thirds of the distance from the centre, with the result that the neutral axis passes through the latter, and the stresses above and below it are equal and opposite to each other.

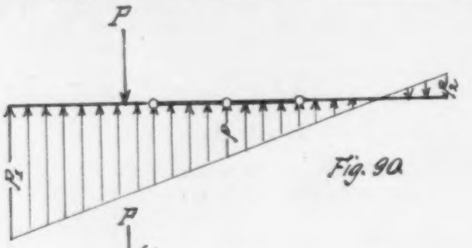

Fig. 90.

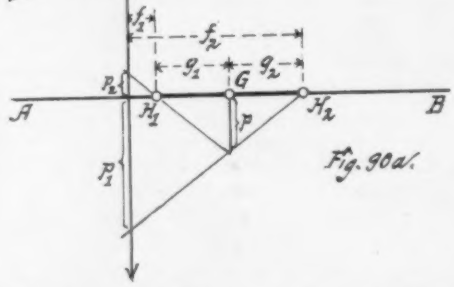

Fig. 90a.

173. Let us return to Figure 85, in which the line *A B* is a side-view of the cross-section. If we now draw the plan, Figure 88, the point of application of *P* with the neutral axis along *b d* would be at 1, at $\frac{1}{6}$ of the width from *a c*. Similarly, with the neutral axis along *c d*, it would be at 2; along *a c*, at 3; and along *a b*, at 4. Joining these points results in a small square, which may be termed the *heart of the cross section*,[1] for, as long as *P* is applied within this space the neutral axis will not cut the section, which will thus be subjected to only one kind of strain throughout.

174. The heart of any cross-section may be constructed by, in turn, assuming every possible line touching, but not cutting, the section, as the neutral axis, and ascertaining the corresponding points of application of *P*. It is not essential to our present purpose, however, to investigate the exact methods of solving a problem of this kind; for we simply intend to make use of the properties of the heart of rectangular sections, in ascertaining the magnitudes of the stresses which result at different points for varying locations of *P*.

If, for any cross-section *A B* (Fig. 89) the magnitudes of the stresses p_1 and p_2 at the extreme fibres are known, the magnitudes of all the remaining stresses can be readily found by connecting the ends of p_1 and p_2 by a straight line *A′ B′*; which will contain the end-points of all the other stresses, as indicated; since all stresses are proportional to their distance from the neutral axis, which would, in this case, be located at the point of intersection of *A B* and *A′ B′* prolonged. It follows that we have only to ascertain the stresses at the two extremities of a section to know all the rest.

175. The heart H_1 H_2 and centre-of-gravity *G* of a cross-section *A B* (Figs. 89 and 89*a*) being known, the stress P_1 at the extreme fibre *A* for a given *P* can be found by means of the formula

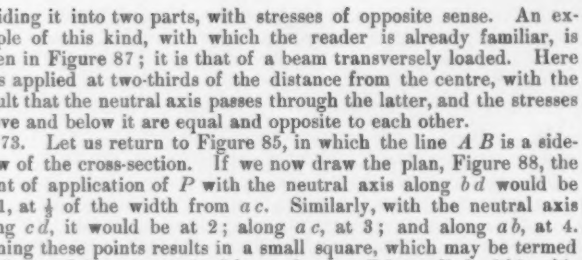

Fig. 91.

$$p_1 = \frac{p f_2}{g_2}, \tag{28}$$

and the stress p_2 at the opposite extreme fibre *B* by

$$p_2 = \frac{p f_1}{g_1}; \tag{29}$$

in which f_1 and f_2 are the distances of *P* from the heart-points H_1 and H_2; g_1 and g_2 the distances of H_1 and H_2 from the centre-of-gravity of the cross-section; and *p* the average stress, which always occurs at the centre-of-gravity (except in the special case mentioned below), and which is found by dividing the force *P* by the area of the cross-section.

The derivation of these formulas is exceedingly lengthy and complicated, involving the application of differential and integral calculus and analytical geometry; space will therefore not permit us to give it here.

176. The values of p_1 and p_2 can be found graphically, as shown in Figure 89*a*. The average stress *p* is placed at the centre-of-gravity, and lines drawn through its ends from H_1 and H_2, cutting off the values of p_1 and p_2 on *P*, as indicated.

For Equation 28 can be written

$$p_1 : p :: f_2 : g_2,$$

which is true of Figure 89*a* on account of similarity of the two triangles of which p_1 and *p* are the shorter, and f_2 and g_2 the longer, legs. Similarly Equation 29 can be written

$$p_2 : p :: f_1 : g_1,$$

which is also found to be the case in the figure.

In Figures 89 and 89*a* *P* is applied within the heart, which results in stresses of the same sense for the entire width of the section, as shown in Figure 89; it will also be noticed that p_1 and p_2 both lie below the line *A B* in Figure 89*a*.

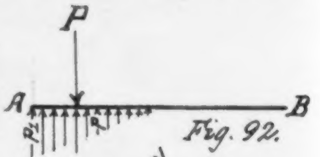

Fig. 92.

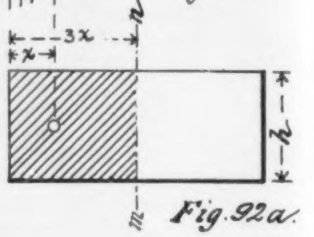

Fig. 92a.

In the next example, Figures 90 and 90*a*, *P* is applied outside of the heart, with the result that the neutral axis cuts the section. While p_1 again lies below *A B*, p_2 lies above it; the two now being of opposite sense.

Very often the force *P* is not normal to the cross-section. In such a case (Fig. 91) f_1 and f_2 are the normals drawn from H_1 and H_2 to *P*. These lengths are projected upon the line *A B*, and verticals drawn through their ends 1 and 2. The lengths of p_1 and p_2 are then found on these verticals by the method used in the previous cases.

177. In applying Equations 28 and 29 to the case illustrated in Figure 90, it is assumed that the cross-section is capable of resisting strains of opposite sense, that is, compression and tension. If this assumption is not permissible, *i. e.*, if the section can only take compression, as in the case of masonry, the force *P* must either not leave the heart at all, or, if that cannot be avoided, the compressive stress at the extreme fibre must be found by a method different from that just given. This is the special case referred to above.

Thus let *A B* be a cross-section acted upon by a force *P* applied outside of the heart, as shown in side-elevation by Figure 92 and in plan by Figure 92*a*. Now, if the section is to be subjected to compression only, it is said that the neutral axis is at a distance of 3*x* from the extreme fibre, if *x* is the distance of *P* from that fibre; and the stress is spread over that part of the section lying between the extreme fibre and the neutral axis, as shown by the shading in Figure 91*a*. The remainder of the section is considered stressless. If the length of the section is denoted by *h*, the area of the shaded portion will be 3 *x h*, and the average stress, occurring at the centre-of-gravity of 3 *x h*, will be $p = \frac{P}{3\,x\,h}$. Inserting *p* in its place, and drawing a line through its end and the neutral axis, gives the stress at the extreme fibre, which will be found to be

$$p_1 = \frac{2\,P}{3\,x\,h}. \tag{30}$$

This formula results in a greater value of p_1 than that given by Equation 28, thus offsetting the effect of disregarding the tensile strain.

178. If we denote the width of a rectangular cross-section by *b*, and its length by *h*, the value of *p* (in Equations 28 and 29) will be $\frac{P}{b\,h}$; and g_1 and g_2 will both equal $\frac{b}{6}$. By inserting these values in Equation 28, the latter becomes

$$p_1 = \frac{6\,P f_2}{b^2\,h}, \tag{31}$$

and, similarly, Equation 29:

$$p_2 = \frac{6\,P f_1}{b^2\,h} \tag{32}$$

In the case of rectangular sections, when it is not desired to use the graphical solution, Equations 31 and 32 will be found simpler and more convenient than Equations 28 and 29.

179. Before going any farther, let us apply the equations just given to an example. A cross-section of brickwork 30″ x 12″ supports a force of 54,000 pounds applied on its long axis, at a distance of 3″ from the centre. What are the stresses along the short sides, and is the section safe? (Fig. 93.) The section being rectangular,

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[1] When only the side of a rectangular cross-section (represented by a single line, as above, in Figures 83 to 87) is taken into consideration, the heart is usually spoken of as the "middle third," being equal, in side elevation, to one-third of the width of the cross-section.

the heart-points H_1 and H_2 on the long axis are each 10″ from the edges of the section, and 5″ from the centre. The average stress p will be $\frac{54,000}{30 \times 12} = 150$ lbs. per square inch. Then, according to Equation 28, the stress along the edge A, that nearest the point of application of the load, will be

$$p_1 = \frac{150 \times 8}{5} = 240 \text{ lbs. per square inch;}$$

and, according to Equation 29, along B,

$$p_2 = \frac{150 \times 2}{5} = 60 \text{ lbs. per square inch.}$$

Or, according to Equation 31, the stress along A will again be

$$p_1 = \frac{6 \times 54,000 \times 8}{(30)^2 \times 12} = 240 \text{ lbs. per square inch;}$$

and, according to Equation 32, along B,

$$p_2 = \frac{6 \times 54,000 \times 2}{(30)^2 \times 12} = 60 \text{ lbs. per square inch.}$$

The safe stress for brickwork laid up in Portland Cement mortar being 200 pounds per square inch, the cross-section would not be safe when loaded as above; applying the load at its centre, however, would make it safe, as the stress would then be only 150 pounds per square inch. An application of Equation 30 will occur farther on.

180. It is evident, after considering the foregoing, that if all parts of an arch are to be subjected to compression only, the line of pressure must cut each joint or section of the arch within its heart or middle third. If, further, the line of pressure happens to cut any joint at the edge of its heart or middle third, the material of which the arch is built must be capable of resisting a compression double the average per unit of cross-sectional area; otherwise the line of pressure must remain within the limits defined by the following equations, which are Equations 28 and 29 solved for f_2 and f_1: —

$$f_2 = \frac{p_1\, g_1}{p} \qquad (33)$$

$$f_1 = \frac{p_2\, g_1}{p} \qquad (34)$$

In these p_1 and p_2, equal to each other, stand for the maximum compressive strain to which the material of the arch can be safely subjected.

Returning to Figure 82, we find that the arch there shown is safe, as the line of pressure lies everywhere within its heart or middle third. If, in the first attempt, the line of pressure cannot be drawn within the middle third, a second trial must be made, after changing the points of application of H and A, which may be assumed anywhere within the middle thirds of the crown and springing joints. Thus both may be applied at the centres of the joints, as we did in Figure 82, which seems the most rational proceeding; or H may be applied at the outer limit of the middle third, and A at the inner limit, which would result in a *minimum* horizontal thrust; or H at the inner limit, and A at the outer, resulting in a *maximum* horizontal thrust.

181. In Figure 82 we drew the line of pressure for an arch-ring carrying only its own weight; let us now draw it for an arch supporting an additional weight of brickwork (Fig. 94); and let us further investigate the effect of the thrust of the arch upon the pier forming its abutment. For convenience in calculating, the arch-ring and the brickwork above it are taken as being one foot in thickness; of course, any other thickness could be assumed as well. Commencing at the crown, the arch and its *surcharge* (superimposed weight) are divided vertically into a convenient number of parts, in this case seven; the first six each 1′ in width, and the last 1′ 3″. It is apparent that the narrower these divisions are made the more accurately can the line of pressure be drawn. It is not necessary to draw the arch-joints. After the weight of each part has been calculated, at 120 pounds per cubic foot, they are combined into a load-line (Fig. 94*a*); the remainder of the operation is then completed exactly like that described above in connection with Figure 82.

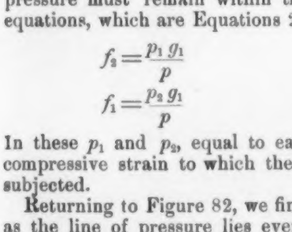

Fig. 93.

We find that the horizontal thrust H is equal to 2,800 pounds, and the thrust A at the abutment, 4,400 pounds. The line of pressure remains within the middle third throughout the entire arch, proving it to be stable.

Let us next ascertain the compression per square inch to which the material is subjected. The area of the springing joint, at which the greatest pressure occurs, namely, 4,400 pounds, is equal to 18″ x 12″, or 216 square inches. The load on this joint is therefore 20.4 pounds per square inch, or only about one-tenth of the safe load on brickwork.

182. Now let us investigate the stability of the abutment pier.

We have acting upon it the force A, which tends to overturn it about the point K. The moment of A about K is $A\,a$, or 4,400 lbs. × 16″ = 70,400 inch-pounds. It is a left-turning moment (§§ 4, 5). Opposed to it is the right-turning moment of the weight of the whole pier, acting about K at the distance l, or 6,830 lbs. × 28″ = 191,300 inch-pounds.[1] This being considerably greater than that of the thrust A, the pier is in no danger of overturning.

183. Having satisfied ourselves upon this point, we next proceed to construct a line of pressure through the pier, to ascertain whether the compression anywhere exceeds the limits of safety. By means of the joints C, E, G, I the pier is divided horizontally into blocks 2′ high, and the weight of each computed. As it enters the pier, the thrust A is immediately acted upon by the combined weight of the blocks I, II and III; the resultant of A and this weight is therefore constructed; its intersection a with the joint G is the first point of the line of pressure. Similarly, the resultant of A and the combined weight of the blocks I, II, III and IV gives a second point of the line on the joint I; and finally the resultant of A and the weight of the entire pier gives a third point on the joint K. The line of pressure can now be drawn through these points. It illustrates clearly how the thrust A, entering the pier at an angle of about 45°, is gradually deflected downward as the weight of each successive part of the pier is brought to bear against it.

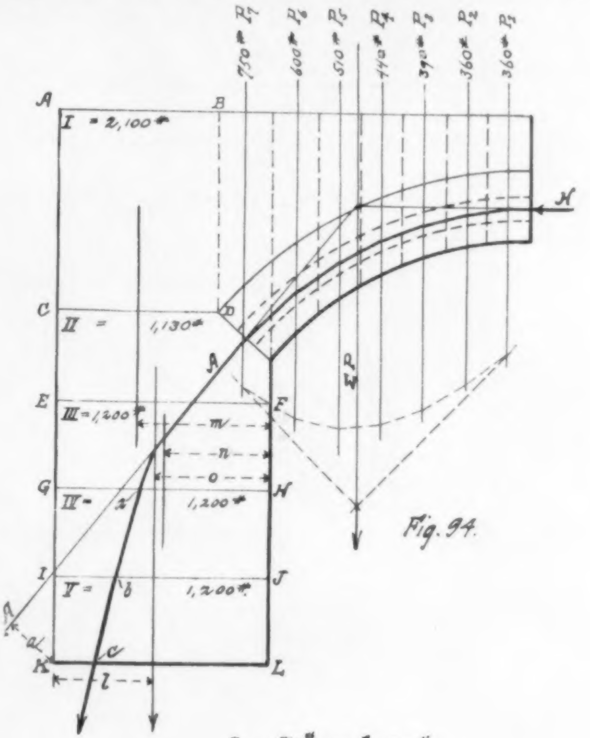

Fig. 94.

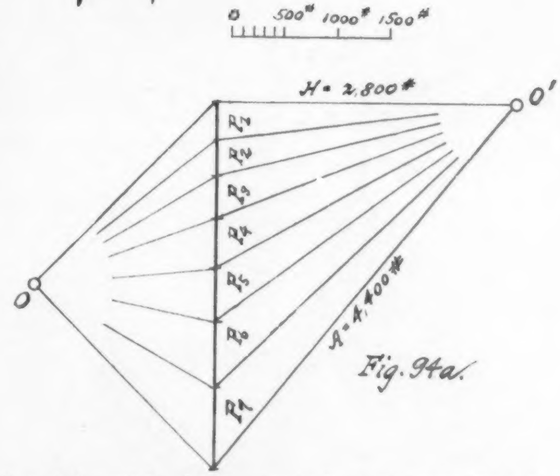

Fig. 94a.

184. The construction of the line of pressure is shown on a larger scale in Figure 94*b*. The weights of the several blocks are all assumed as acting through the centre-of-gravity of the entire pier.

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[1] The weight 6,830 pounds acts vertically through the centre-of-gravity of the whole mass. This centre-of-gravity is found by ascertaining the resultant of the weights of the two parts $A\,B\,C\,D$ and $C\,D\,K\,L$. This can be done either graphically, by means of a cord-polygon, or analytically, by taking the moments of the two weights about the line $F\,L$, and finding at what distance from $F\,L$ the sum of the two weights must be applied in order that its moment may equal the sum of the first two moments.

Thus the moment of $A\,B\,C\,D$ about $F\,L$ is 2,100 lbs. × 3.12′ (m in the figure), or 6,550 foot-pounds; and that of $C\,D\,K\,L$, 4,730 lbs. × 2.5′ (n in the figure), or 12,100 foot-pounds; together, 18,650 foot-pounds. The sum of the two weights is 6,830 pounds, which, in order to give a moment of 18,650 foot-pounds about $F\,L$, would require a lever-arm of $\frac{18,650}{6,830}$, or 2.83′ (o in the figure). This, then, is the distance of the centre-of-gravity from $F\,L$.

This assumption is slightly erroneous in the present case, but of great advantage in simplifying the diagram. From the point of intersection (1) of A with the vertical through the centre-of-gravity the weights of the several blocks 1–3, 3–5, 5–7 are laid off. The amount of A is then laid off from the point 3, in the proper direction, and again from the points 5 and 7. The sides 1–2, 1–4, 1–6 of the three force-triangles are then the successive resultants of A and 1–3, 1–5, and 1–7. They locate the points a, b and c of the line of pressure on the joints G, I and K, as already described.

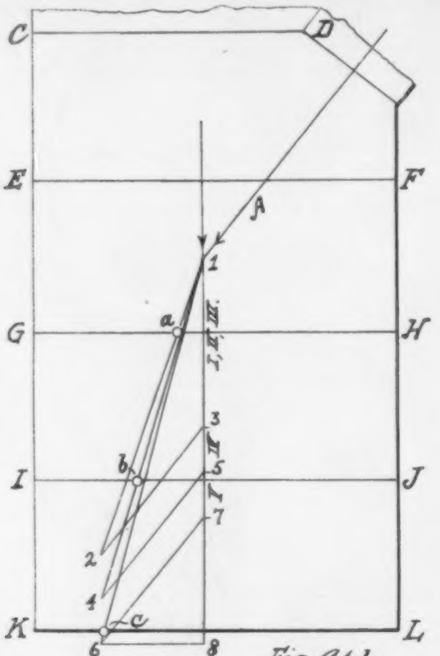


Fig. 94.b.

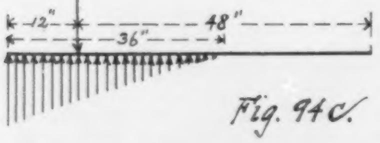


Fig. 94c.

If the line of pressure should happen to cut any joint at a lesser angle than 30° the part above the joint would have a tendency to shear or slide off. Such a case, however, rarely occurs; when it is unavoidable dowels must be inserted between the blocks to keep them in place.

185. The final pressure on joint KL is given by the length 1–6. This can be resolved into a horizontal and a vertical component, equal to 2,750 and 10,250 pounds respectively. The former is counteracted by the friction and adhesion existing at the joint, and may therefore be disregarded. The vertical component is applied on the joint KL at a distance of 12″ from the edge. The joint being 60″ wide, its point of application therefore lies outside the heart, giving rise to both compressive and tensile strains. As we cannot count on a tensile resistance, we must apply Equation 30, and find the extreme fibre stress at the edge K to be

$$p_1 = \frac{2 \times 10{,}250}{3 \times 12 \times 12} = 47.5 \text{ lbs. per square inch;}$$

and the average stress for the stress area, which is 36″ wide (§ 177).

$$p = \frac{10{,}250}{3 \times 12 \times 12} = 23.7 \text{ lbs. per square inch.}$$

As both of these amounts are very much below the maximum safe compression permissible for brickwork (200 pounds per square inch), and since the pressure on the upper joints is even less, and more favorably applied, we need not hesitate to pronounce the entire construction safe.

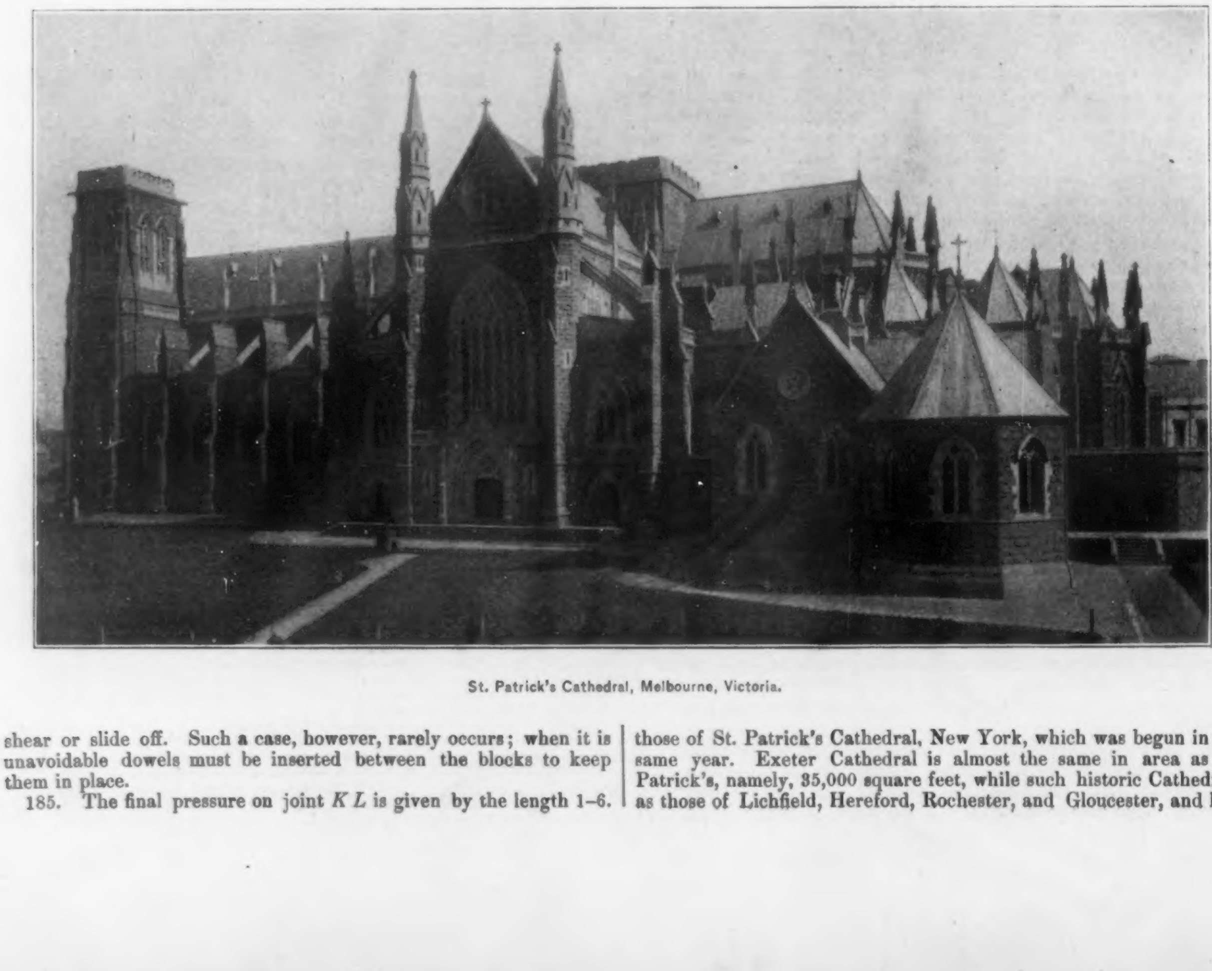
O. F. Semsch.

(To be continued.)

ROMAN CATHOLIC AND ANGLICAN CATHEDRAL IN MELBOURNE AND SYDNEY.

Sydney, N. S. W., December 6, 1897.

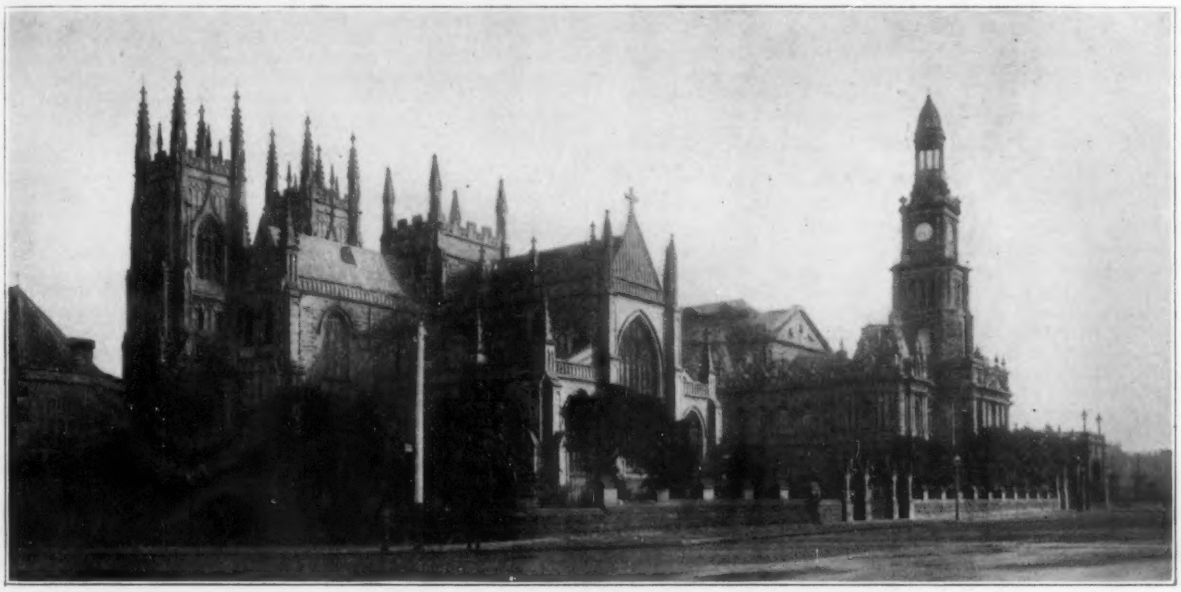
St. Patrick's Cathedral, Melbourne, undoubtedly the most important ecclesiastical edifice in Australia, was opened last month with much pomp and ceremony by the Cardinal-Archbishop of Sydney, assisted by a host of lesser dignitaries. The building has been in course of erection for many years, and has cost over £200,000 without the spires. The Cathedral is very happily situated, and commands a central position, overlooking the City of Melbourne, and, next to St. Mary's Cathedral in Sydney, is the finest example of Decorated Gothic south of the equator. It is of the usual cruciform shape, with a central tower and spire at the place of intersection, and the smaller towers and spires flanking the nave at the western end. The dimensions are as follows: nave, sanctuary, and Lady Chapel, clear internal length, 320 feet. Nave and aisles, and transepts and aisles, internal width, each 76 feet. Transepts, internal length, 162 feet. Height of main roofs to ridges, 98 feet. Height of western towers and spires to be 203 feet. Height of central tower and spires to be 260 feet. These measurements are only slightly smaller than those of St. Patrick's Cathedral, New York, which was begun in the same year. Exeter Cathedral is almost the same in area as St. Patrick's, namely, 35,000 square feet, while such historic Cathedrals as those of Lichfield, Hereford, Rochester, and Gloucester, and half



St. Patrick's Cathedral, Melbourne, Victoria.

a score of others in England and Scotland are smaller in area. When the central spire is erected there will be only four higher in England. The bluestone of which the Cathedral is built — the dressings alone being of the lighter freestone — gives to the exterior of the building a sombre and even gloomy aspect. The pinnacles are richly carved, and infinite pains have been bestowed upon the tracery of the fine windows, and the embellishments of the numerous entrances. The doors are deeply recessed, and the arches are beautifully carved and moulded. All the carving is in freestone. The architect is Mr. W. W. Wardell, F. R. I. B. A., now of Sydney.

The Roman Catholic Cathedral in Sydney is also the work of the same architect, and though only half built, promises to be when completed a far finer building than St. Patrick's. The material used in its construction is a brown freestone of a warm tone, and this alone lends it a charm which is altogether lacking in the gloomy, and almost repellent, exterior of the Metropolitan Catholic Church of Melbourne. A contract has just been entered into for the completion of the transepts and the central tower of the Sydney Cathedral, at a cost of £26,000. About six times this amount has already been expended, and the greater portion of the nave, and the western towers and spires have still to be erected. Neither the Anglican Cathedral of St. Andrew in Sydney, nor that of St. Paul, Melbourne, can compare with the Catholic cathedrals in those cities either in point of size or architectural effect.



St. Andrew's Cathedral. E. Blacket, Architect, and the Town-hall, Sydney, N. S. W.

At the first general meeting of the Institute of Architects of New South Wales, held on November 17th last, the following gentlemen were appointed officers for the session 1897–98: *President*, Mr. J. B. Barlow; *Vice-President*, Mr. H. A. Wilshire; *Honorary Treasurer*, Mr. W. Pritchard; *Honorary Secretary*, Mr. G. Sydney Jones, A. R. I. B. A.; *Council:* Messrs. Thomas Rowe, F. R. I. B. A., C. Backhouse, T. Kirkpatrick, J. A. Kethel. Messrs. M. C. Day and Halloran were appointed Honorary Auditors.

THE ILLUSTRATIONS

[*Contributors of drawings are requested to send also plans and a full and adequate description of the buildings, including a statement of cost.*]

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THE GRAND FOUNTAIN, VITERBO, ITALY.

ACCEPTED DESIGN FOR THE SOLDIERS' MONUMENT, JERSEY CITY, N. J. MR. PHILIP MARTINY, SCULPTOR; MESSRS. ACKERMAN & ROSS, ARCHITECTS, NEW YORK, N. Y.

[The following named illustrations may be found by reference to our advertising pages.]

PALAIS DES ARMÉES FOR THE EXPOSITION OF 1900. SCHEME OF MM. AUBERTIN & UMBDENSTOCK.

MONUMENT TO CHARLET, PARIS, FRANCE. M. CHARPENTIER, SCULPTOR.

THIS and the preceding plate are copied from *La Construction Moderne*.

FIREPLACE IN THE SALLE DU TRÔNE, PALAIS DU LUXEMBOURG, PARIS, FRANCE.

[Additional Illustrations in the International Edition.]

PARLOR: DETROIT CLUB CLUB-HOUSE, DETROIT, MICH. MR. WILSON EYRE, JR., ARCHITECT, PHILADELPHIA, PA.

[Gelatine Print.]

STAIRCASE HALL IN THE SAME BUILDING.

[Gelatine Print.]

RESIDENCE, LEICESTER WATER-WORKS, LEICESTER, ENG. MR. J. B. EVERARD, ARCHITECT.

GLOUCESTER CATHEDRAL FROM THE CLOISTERS, LOOKING SOUTHEAST.

COMMUNICATIONS

[*The editors cannot pay attention to demands of correspondents who forget to give their names and addresses as guaranty of good faith; nor do they hold themselves responsible for opinions expressed by their correspondents.*]

"GOOD CITIZENSHIP AND THE BEAUTY OF CIVIC SURROUNDINGS."

NEW YORK, N. Y., January 29, 1898.

TO THE EDITORS OF THE AMERICAN ARCHITECT: —

Dear Sirs, — From what report of my remarks at the Reform Club your information was drawn that makes me cut so ridiculous a figure in your editorial comments of to-day I cannot say; but kindly believe my allegation that "I said no such thing," or at least made no such deductions. My picture of the porticos of Rome and Hadrian's villa was drawn, in order to illustrate the practical view — combined with taste — the Romans took of weather protection, — protection against the tramontana blasts of winter and the hot rays of summer.

As a rule, it is hardly worth while to correct the inaccurate reports of the press, but having had in times past very friendly, as well as professional, relations with your journal, you will do me the favor to print this communication. Faithfully,

Frederic Crowninshield.

THE PHŒBE A. HEARST ARCHITECTURAL PLAN.

New York, N. Y., January 29, 1898.

To the Editors of the American Architect: —

Dear Sirs, — For the information of your readers, especially architects in and around Brooklyn, N. Y., I desire to state that map of the ground, plaster model showing contour of ground, and programme of competition for the University of California, "The Phœbe A. Hearst Architectural Plan," are now on exhibition in the Art Buildings, Montague Street, Brooklyn, N. Y., where any one may examine them, and, if they desire to compete, can obtain a programme and map. Very truly yours,

A. G. Thomson, *Secretary.*

"FIREPROOF BUILDINGS: THE BURNLEY FIRE."

New York, N. Y., January 31, 1898.

To the Editors of the American Architect: —

Dear Sirs, — In your issue of January 29th you publish an article on the fire in the New Hall Spinning Mill Co., at Burnley, England, with illustrations of the subsequent wreck, as also of the manner of construction. You state: "this is the second mill in England within seven years, of fireproof construction, which has collapsed through the effects of internal fires." The illustrations show that not a single column, beam or girder was protected; is it not a misnomer to call a building so constructed "Fireproof"?

The report says: "columns and beams were giving away before the steamers got to work and the fire had practically to be allowed to burn itself out." "Considering that the only fuel was the woodwork of mules and the rovings and bobbins in creels, with the finished yarns, it is incredible how the place became such a complete wreck, for the whole of the floors and roof were broken in."

In view of recent experiments on cast-iron columns, it would have been more incredible still had anything but a total collapse resulted from such defective construction.

A careful study of the series of articles published in *Engineering*, by Edwin O. Sachs, architect, with illustrations, shows conclusively the small resistance offered by unprotected iron the moment a fire has any force; but not many realize what slight development of heat can be fatal to a large structure; he cites the instance of the canvas in a panorama at Vienna catching alight and in the shortest space of time destroying the roof of the building in such a manner that the whole of the constructional work could be only dealt with as old iron.

Cast-iron columns when unprotected collapse at a temperature of about 1382 degrees Fahrenheit, and, if at all spongy in parts, will most probably fly into pieces through quenching, even though such a temperature be not reached; cast-iron beams may also be fractured with cooling. Here is probably the explanation of the phenomenon noted.

You recommend covering all iron with concrete as a protection which may retard the collapse; we beg to differ with you. . . . While there is no doubt that a covering of Portland cement concrete will afford some protection to a metal column or girder, still there appears to be no doubt that the concrete itself will be ruined by the action of the fire and when heated will not stand the subsequent application of water — a very important point when we consider the immense amount of water thrown into a building during a conflagration. The concrete is then sure to break off, leaving the ironwork bare.

X. Y. Z.

[It may be worth while to point out that the language which our correspondent criticises is contained not in Mr. Atkinson's comments but in the report of the English experts. — Eds. American Architect.]

NOTES AND CLIPPINGS

Electrolysis on the Bridge. — The opponents of the extension of the Brooklyn trolley systems across the New York and Brooklyn Bridge have brought up a new and quite interesting argument concerning the possible effect of the return-currents on the main structure. It is claimed that the return-current will seek the bridge structure and return via the main support-cables to the Brooklyn end, thence going to ground on its way to the power-house. Although this seems rather unlikely, on account of the fact that the tracks on the bridge proper are laid on the wooden flooring and are hence fairly well insulated, still there remains an uncertainty about the currents from the New York approach, in which the tracks are laid in the ordinary pavement. Large currents will necessarily return from these tracks to the power-house, owing to the heavy grade and the great number of cars which will pass over it, and current tending to return by the ground will naturally seek the continuous steel cables of the bridge, passing into them at their New York anchorage and out from them at their Brooklyn anchorage, and thence on to the source of supply. Just what is the resistance of concrete, such as these anchorages are buried in, to the passage of currents, and just what electrolytic action takes place when currents pass between metal and concrete, is not apparently very well known, but the question should certainly be thoroughly settled before a simple ground return is allowed on the bridge, owing to the enormous risk which the slightest uncertainty would involve. The trains now running over the bridge, although hauled by cable for the major part of the distance, are switched at the termini and lighted and even propelled at night by electric power supplied from the third rail and returned through the service-rails. These rails, however, all being on wooden sleepers, are probably sufficiently well insulated from the bridge structure to prevent any serious leakage. Some such system of third rail, or extra conductor, either overhead or to one side of the car, might be adopted for the bridge section of the Brooklyn trolley system, but would necessitate the equipment of an enormous number of cars with apparatus only used for a short part of their trip. A better plan might be to maintain, by extraneous means, the difference of potential between the ground at the two ends of the bridge at zero, a further advantage of this plan being the probability that there is already a difference of potential sufficient for slow electrolytic action, even with no electric power on the bridge itself. The question seems to be one that has not been brought up before, and it may be worth while to look into the matter in case of other bridges. — *The Electrical World.*

Forest Fires caused by Lightning. — According to Dr. Bell, in *The Scottish Geographical Magazine*, the forest fires of Canada are generally caused by lightning. In the great forest between Alaska and the Straits of Bellisle the portions recently burned are easily recognized by the tenderer green of their foliage from the parts which have been longer spared. The fire rushes along with the speed of a galloping horse. The branches and dead leaves on the ground burn like tinder, and the flames rise to nearly 200 feet. Resinous pinewoods burn fastest. One of them extended 160 miles in ten hours. The traces of a fire remain for nearly a century. Birds and beasts are stifled or burned. Beavers and muskrats, which are amphibious, have a chance of saving their lives. After the fire a few trunks of the largest trees are left. Next spring roots begin to sprout and seeds to grow. In fifteen or twenty years the soil is covered with poplars, willows, etc., which shelter young firs and other trees. In fifty years the conifers are uppermost, and in one hundred the others are dying out beneath the pinewood. A third of the forest region of Alaska has trees of fifty years old, another third, trees of fifty to one hundred years, and the rest, trees over one hundred years old. The fire seems to suit the Banksian pine, as it opens the pines and sets free the grains. Without fires this species would hardly reproduce itself. Such fires took place even in the Pleistocene epoch of geology.

British Museum once more closed at Nightfall. — The experiment of opening the exhibition-galleries of the British Museum every evening for the benefit of the classes which have no leisure during the day has proved a failure, and will be abandoned. It was begun in February, 1890, on the installation of the electric light, the galleries, however, being opened only in sections, as the electric plant is not powerful enough to light up the whole building. At first the eastern and the western parts of the Museum were opened on alternate week-day evenings, but the number of visitors so rapidly declined that the galleries were afterwards further subdivided into three sections. The number of visitors, however, still continued to decline. The experiment, having thus had a fair and patient trial, will now be abandoned, and a longer exhibition by day will be substituted, during the months when the Museum has hitherto been closed at 4 p. m. or 5 p. m., according to the season of the year. Hereafter the galleries will be kept open throughout the year from 10 a. m. to 6 p. m., with this reservation, however, that during the dark hours when the electric light has to be employed only half of the Museum (the eastern and the western galleries alternately) will be opened to the public. The arrangements for opening on Sunday afternoons will not be altered. — *N. Y. Evening Post.*

Right to maintain Windows in Party-wall. — Alonzo E. De Baun and Stuart H. Moore severally acquired from a common grantor adjoining premises separated by a party-wall, of which a portion furnished support for structures on both lots, while the remainder supported only the house of Moore, and contained windows overlooking De Baun's premises. In a suit brought by De Baun, in Kings County, to restrain Moore from maintaining openings, or windows, in this party-wall, and to compel him to close the openings wherein the windows are by filling-in the space with solid brick masonry, the Second Appellate Division, in an opinion by Justice Hatch, has affirmed the judgment below in favor of the defendant, holding that De Baun, who knew of the existence of the windows at the time he took title, cannot compel Moore to close the windows, unless their existence deprives him of the beneficial use of the wall to which he is entitled. — *N. Y. Times.*

The English Fire-inquest. — The peculiar custom of holding inquests on fires in the City of London, even where no life has been lost, dates back to a period when 4*d* per day was the regulation fee of the juryman, and was probably equal in purchasing power to at least four times its present value. The custom, after having been pronounced by one of her Majesty's judges to have fallen into desuetude, was revived and renewed by the Corporation in its London Inquests Fire Act of 1888, and has been in frequent use since that date. These investigations and pronouncements are of considerable importance, especially to the insurance companies. — *London News.*

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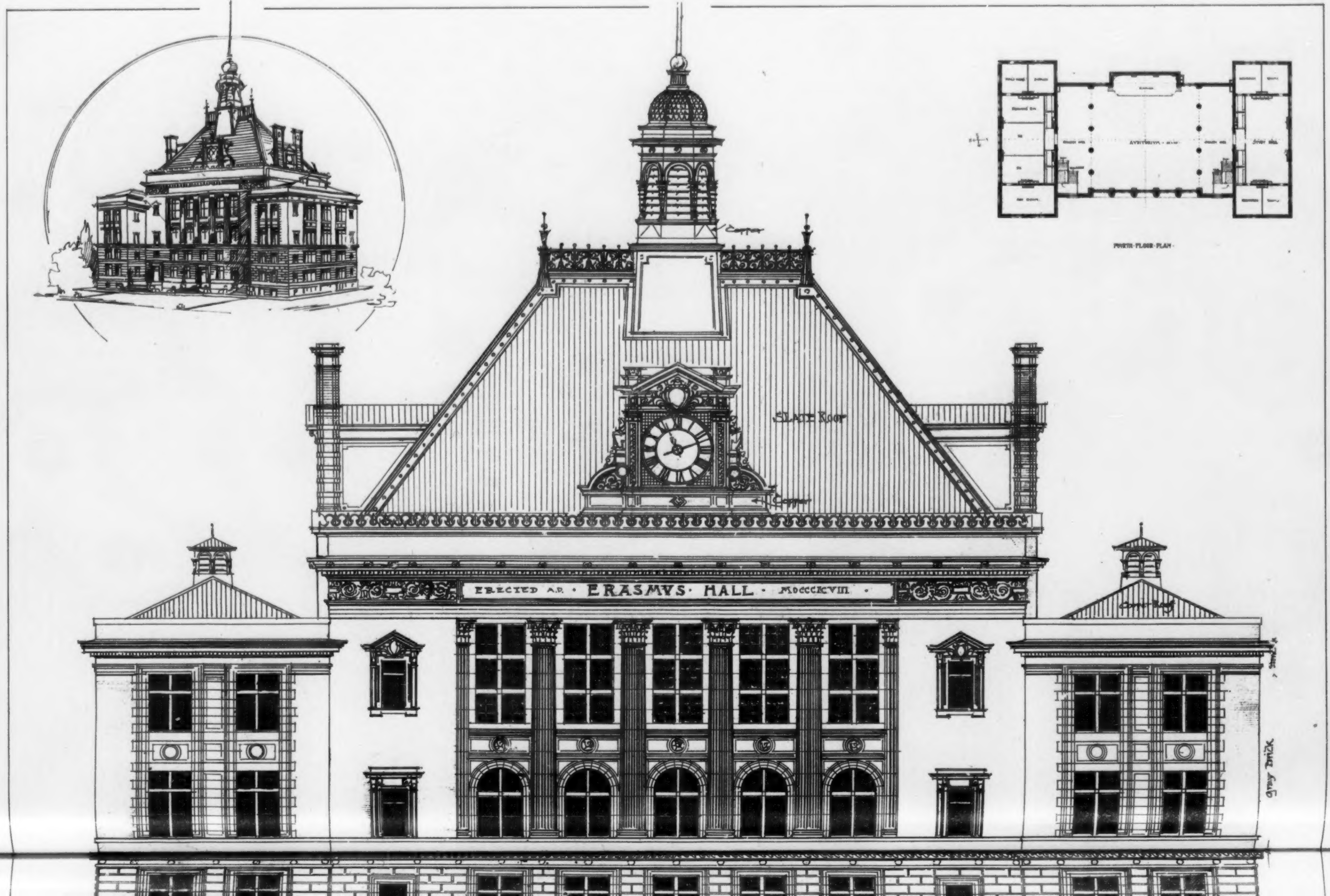
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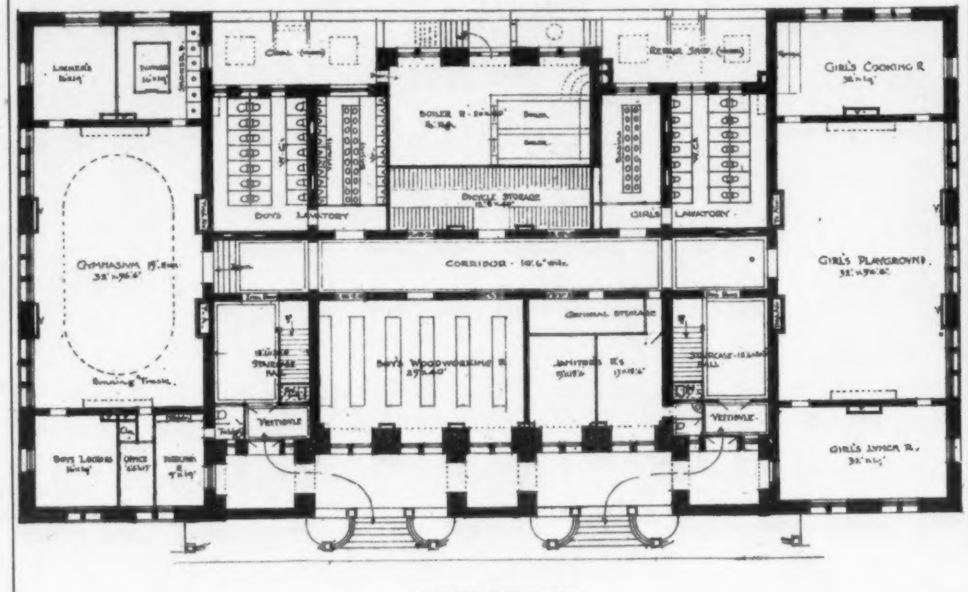

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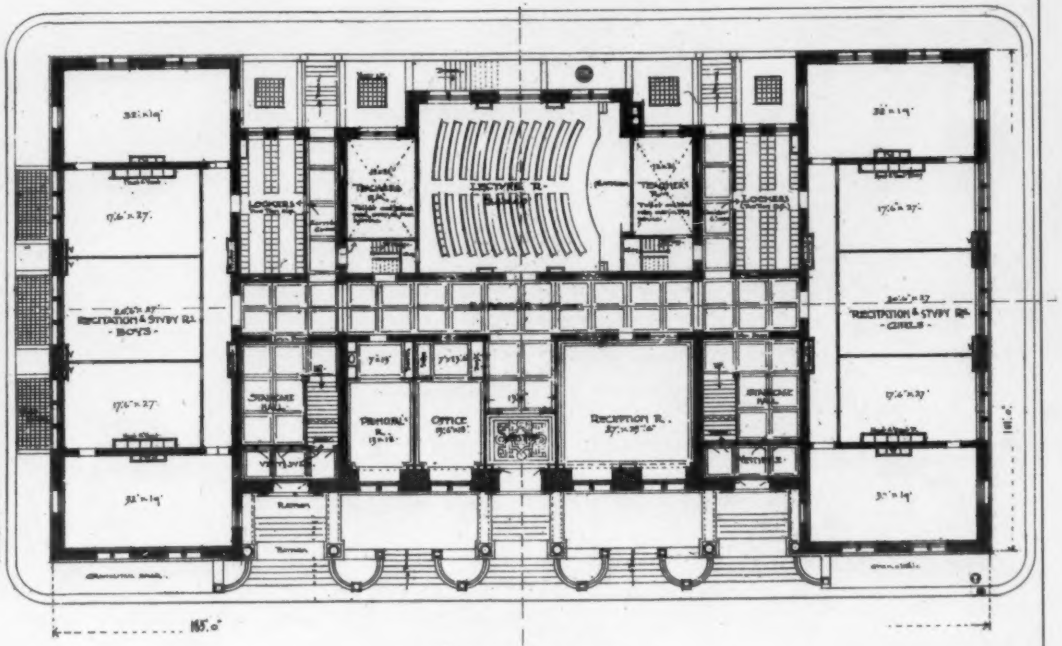

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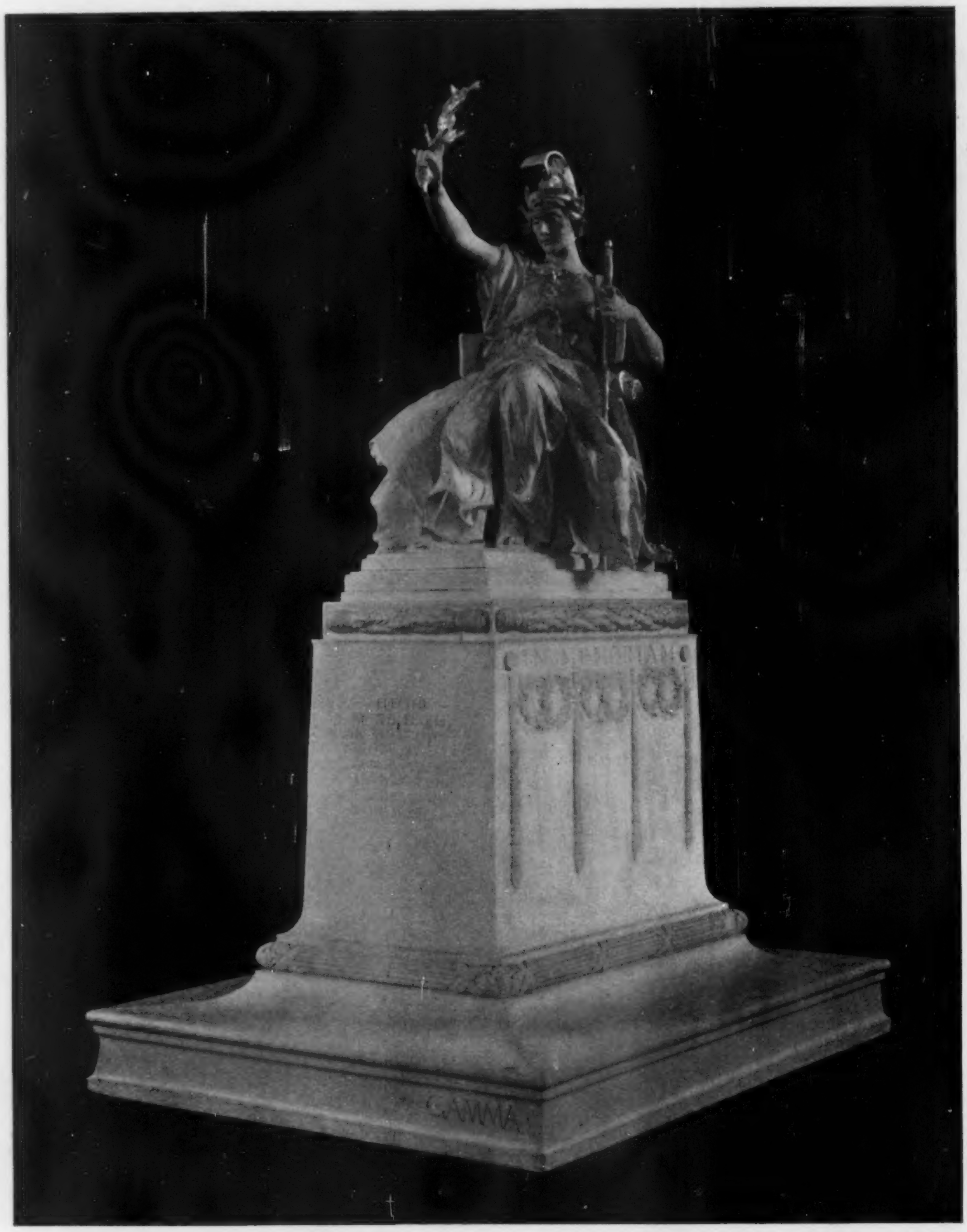

Jersey City Soldiers' Monument, Jersey City, N. J.

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THE GRAND FOUNTAIN, VITERBO, ITALY.

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