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CONTENTS

ANOTHER bill to restrict the height to which buildings may be carried in New York is likely to be introduced in the Assembly at Albany this winter, and it seems quite probable that it may pass. The *Evening Post*, in speaking of it, mentions certain considerations which will weigh in favor of restriction, and which are daily becoming of more importance. Among these is the circumstance that the erection of lofty office-buildings in New York is by no means as profitable an operation as it was a few years ago. It is well known among real-estate agents that the "office population" in New York, as in other large cities, does not increase rapidly, and the supply of new offices has of late very much outstripped the demand. It is true that the attractive offices in the new fireproof buildings draw tenants from the old ones, but the supply even from this source is running short, and the *Evening Post* says the total rental of some of the new "sky-scraper" buildings is less than half what it was when they were first erected, a very few years ago. As the cost of maintaining a building of this sort, including that of fuel, elevator and janitor service, care and repairs, is just as large when the rents are low as when they are high, there is now little inducement for owners of land in anything but the most favored locations to risk large sums of money in what may be a losing speculation, and the owners of land in such less favored localities, instead of opposing a restrictive bill, as they have done hitherto, are likely this year either to cease opposition, or to advocate its passage, for the very good reason that if a building of moderate height is the safest investment for them, they will be much surer of getting tenants for such buildings if the competition of the "sky-scrapers" is checked. In Chicago, in the same way as in New York, the mania for lofty structures raged for a few years to such an extent that enormously high office-buildings, erected in situations where there was no demand for offices, have been let for storage ever since their completion; and the lesson seems to have been so far taken to heart there that little opposition was made to the severe restrictive law now in force there.

IF the people who thought, a year or two ago, that they might like to build a twenty-five story office-building on their land, have really moderated their ideas so far as not to oppose actively a statute to restrict heights of buildings, the law ought to pass without difficulty, for the owners of existing high buildings are, of course, unanimously in favor of a restriction which secures to them their monopoly, while, among the disinterested people, the architects, fire-engineers, building-inspectors and health-officers are pretty well agreed that restriction is necessary in behalf of the public. Of course, the prospect of the passage of such a bill would lead to the hurried starting of many "sky-scrapers" by people anxious to take advantage of their last opportunity; but this could not be avoided in any case, and it is safe to say that, of the plans of the kind hurried through the building department, a good many would never be carried out, while the owners of some of the buildings really executed would bitterly repent their haste.

SINCE the publication, some two years ago, of Professor Greenleaf's curious paper on "Window Lights," in the *Popular Science Monthly*, a good deal of attention has been paid to the subject of reflected light, and the relative value of light from the sky, and the reflected rays from different substances, has been carefully observed. In these days of lofty buildings, many rooms and offices in our cities never receive anything but reflected light, and the quality of that reflected light is of the utmost importance. To a banker, for example, occupying a first-story office on a narrow street, with a twenty-story building opposite, the color of the twenty-story building is a serious matter. If it is of dark red brick, or dark stone, his office will be dark all day long, his clerks will have to work by artificial light, and his customers will go away with a feeling of dislike to the gloomy rooms, which is very likely to result in the transfer of their business to houses occupying more cheerful quarters; while, if the opposite structure is of marble, or light-colored stone or brick, the brightness of the light reflected from it will add greatly to the attraction of bankers premises. In one new building that we know of, in a narrow street, the front is entirely of white enamelled brick; and it is well worth considering whether the owners of structures more than six stories high should not be compelled by law either to paint them with an enamel paint, which the rain would wash, or to face them with light-colored brick or stone.

THE New York papers give, incidentally, warning of a scheme which we hope will be nipped in the bud by the courts. It seems that the labor troubles which some one has been successful in getting up on the St. Paul building have revived the energies of the Board of Walking Delegates, which had rather drooped since the election. At a meeting of these functionaries the other day, it was resolved to "extend the strike" to another large building which is being erected by the same contractor, and attempts are being made to get some of the workingmen's organizations, which reject the authority of the Walking Delegates, back into the fold. Among these stray sheep is the Plumbers' Union, and, according to Delegate Henry, of the Board of Walking Delegates, as his words are reported in the *Times*, the Master-Plumbers' Association is not only willing, but anxious, that the journeymen's union should return to its allegiance. Why the master-plumbers should wish to see their men placed again under the authority of an organization which has tormented New York employers in many cases into bankruptcy, and in some into their graves, is not very evident, but the clue to the mystery can be gathered from what follows: "The members of the Master-Plumbers' Association," we are told, "and their union journeymen have a contract that the former should employ only union men, and the union men, on the other hand, will work for none but members of the Master-Plumbers' Association. Should the Plumbers' Union return to the Board of Walking Delegates, the latter will order general strikes against all non-union plumbers, wherever they may be found." The interpretation of this is plain enough. The members of the Master-Plumbers' Association and the Plumbers' Union have found that their arrangement, by which the former hoped to exclude competition by preventing master-plumbers outside of their own number from getting competent men to work for them, while the latter hoped to prevent non-union plumbers from getting employment, does not work so well as they had wished, and that there are some plumbers, both masters and men, who are earning an honest living by doing plumbing work without asking their leave; and they, or some of them, have taken it into their heads that it would be a good thing to invoke the fearful power of the Board of Walking Delegates to aid them in crushing their rivals. Of course, the price of such assistance would be their own submission to the tyranny from which they have only recently extricated themselves, but people who call upon Satan to aid them in their quarrels with other people seldom think how the prongs of his trident will feel when he turns it against them afterward. Meanwhile, the poor people who imagine that American liberty applies to plumbers in New York have a hard lesson in store for them, for if the Walking Delegates, in concert with the Plumbers' Union, and the Master-Plumbers' Association, carry out their plans to "order general strikes against all non-union plumbers, wherever they may be found," there will be nothing for non-union plumbers to do but go to the almshouse with their families.

ONE of the aspects of the park question, which is now being discussed, relates to the value of park lands as an investment for public funds. The City of New York, for example, has about five thousand acres of land devoted to parks and squares. For this land about thirty millions dollars have been paid, but it is said that the City Hall Park alone, containing about eight acres, would bring nearly or quite that amount, if put on the market, and that the total salable value of all the parks would be at least ten times their cost. It may be worth while to point out that this way of looking at the matter is misleading, for the simple reason that the park lands cannot be sold. That they have been well worth their cost, in the increase of taxable value of the property around them, is undoubted, but municipalities, in considering park systems, should consider this increase of value, rather than the possible selling at a profit of land once taken for park purposes. Under ordinary circumstances, land taken for parks is forever dedicated to public use, and could not be sold for building, and it is hardly necessary to say that a park laid out under such conditions that it might be cut up later and sold, would be anything but an attraction to property-owners, and the valuations of land in its vicinity would be lower, under the uncertainty as to the future destiny of the territory, than they would be without any park.

REGARDED as an undertaking for the perpetual benefit of the public, the laying out of parks is a matter to which too much time and thought cannot be given. In nearly all cases, the establishment of parks is the work of land speculators, following their private advantage, without regard to that of the public. The moment a public demand, stimulated or suggested, in many cases, by the speculators themselves, finds expression in the newspapers, a dozen rival syndicates begin to urge the "claims" of their respective plans, each having a tract of land, of which they would like to sell a portion to the municipality, at a good price, and the rest to investors, at a value greatly enhanced by the neighborhood of the new pleasure ground. There is no end to the absurdities of these eager schemers. We once knew a case where a plan was extolled for weeks in the local papers, and strongly urged upon the municipal government, for buying for a "park" a portion of a large tract of forest land, whose principal claim to distinction lay in the fact that wild-cats were occasionally killed there, while one of its few inhabitants, commenting on the argument, which is universally made in such cases, that "the value of the land is rapidly increasing, and it must be secured before the cost becomes prohibitive," observed that he, for one, would be glad to sell his land for less than had been offered for it forty years previously. In this instance the scheme was so obviously ridiculous that it fell through, but many another, perhaps as foolish, is, by means of political and other influences, carried out at the expense of the public.

THE true way to lay out parks is to do so without any assistance from speculators, or any notice to them, employing only the aid of expert park designers. After these have thoroughly examined the ground, and made their sketches, the Commissioners, or whoever may be charged with representing the municipality in the matter, should consider what important interests, if any, will be affected by the plan; and, after the necessary modifications are made, the design should be carried out to the letter, without paying the slightest attention to the howls and execrations, the flatteries, cajoleries, wire-pulling or threatening of the swarm of speculators which will be aroused by its publication. It was in this way that the matchless chain of parks adorning Boston was designed, and two open sewers with their banks converted, without any help from speculators, into the brightest and most attractive of driveways, leading for ten miles through what will be in a few years the heart of a great city; yet the cost of the Boston park system has been less by many millions than that of most city parks of equal area, while its effect in improving property values in the neighborhood promises, on account of its extended perimeter, as well as its natural beauty, to be very great.

NOTWITHSTANDING the collapse in value of shares of the Acetylene Company, which, after being quoted at four hundred dollars, are said to have been recently sold for fifty cents, acetylene has a certain future before it. For obtaining a brilliant light, under circumstances where no other light would be available, it offers peculiar advantages, and, as appliances for utilizing it are improved, it seems reasonable to anticipate its increasing use. Meanwhile, architects, who are quite likely to be consulted in regard to the introduction of fittings adapted to it, will do well to bear in mind the conditions under which it can be safely employed for illuminating purposes. The most important of these is, undoubtedly, that neither the gas, nor the calcium carbide, nor the water which is used to generate the gas, should be allowed to come in contact with brass or copper in any form, in pipes, fixtures, valves, or otherwise. On the first introduction of calcium carbide as a gas-producing material, the French and German chemists called attention to the fact that acetylene forms with copper a highly explosive compound, the acetylide of copper, and iron burners must be used with it. Some of the people interested in the acetylene speculation ridiculed this notion. It was asserted, with the usual confidence of speculators, that no such action could take place in the ordinary use of acetylene in brass gas-fixtures; and when certain occurrences cast doubt on the correctness of this theory, it was asserted that, in any case, chemical combination of the gas with brass or copper could take place only where the metal was already corroded. Even chemists were for a time misled by this notion, but it is now certain that the commercial acetylene, as produced from calcium carbide, acts vigorously on clean surfaces of brass and copper, producing the characteristic explosive compounds. A few weeks ago, an English chemist, a manufacturer of compressed oxygen for the trade, who had long been experimenting with acetylene, was using a steel cylinder for receiving the gas, which was led into it through new copper pipes with new brass fittings, when a violent explosion took place, accompanied with a flash of light. Fortunately, no one was injured, and, on examining the pipes and fittings, they were found deeply honeycombed on the inside, evidently from the action of the gas. The steel cylinder was, of course, not corroded, but was found to be lined with a coating of soot, showing that the explosion was produced by spontaneous decomposition of the gas, and not by excessive pressure. A similar indication was given in an accident in France, where a cylinder of compressed acetylene exploded in the street, killing a man, whose body was found covered with fine carbon dust, evidently produced by the decomposition of the gas. The explosion which took place in Connecticut some months ago was probably due to the same cause as the others, although it has never been scientifically investigated, so far as we know. It is said, moreover, that commercial acetylene is often contaminated with phosphorus. What the phosphorus could be derived from is not very clear, but it is hardly necessary to say to any one who has seen the bubbles of phosphoretted hydrogen flash up on emerging from the water in the familiar lecture-room experiment, that compounds of phosphorus and hydrogen take fire spontaneously on contact with the air.

MR. G. W. G. FERRIS, the designer of the famous Ferris' Wheel, which formed one of the most popular of the outside attractions at the Chicago Exposition, died a few days ago in a hospital in New York, of typhoid fever, brought on in part, it is said, by anxiety over business matters. Mr. Ferris was born in Galesburg, Illinois, and graduated from the Rensselaer Polytechnic Institute, at Troy, as an engineer. After several years' practice as an assistant, he began business on his own account as what might be called an inventing engineer. The Chicago Exhibition suggested to him the extraordinary plan which he worked out with such signal success, and which is said to have brought him a fortune.

STATICS OF STRUCTURES. — THEORETICAL AND APPLIED. — I.

INTRODUCTORY. — SIMPLE BEAM WITH UNIFORM LOAD.

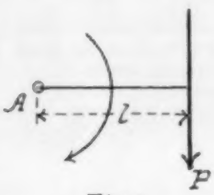


Fig.1.

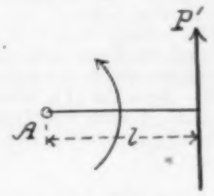


Fig.2.

1. It is the purpose of this science to investigate the conditions under which the forces acting upon any body will be in equilibrium.

A *force* is fully defined when its amount, position and direction are known. Its direction, together with a point through which this direction passes, gives its position.

Forces may be divided into two classes: those lying in the same plane, or *co-planer forces;* and those lying in different planes, or *non-co-planer forces.*

2. It is apparent from these definitions, that a force may be represented graphically, the paper being the plane, the force a straight line, drawn to a scale of so many pounds to an inch, with perhaps an arrow at one end to indicate the direction in which it is acting.

3. *The moment of a force* about a point is the product of the amount of the force (taken in pounds) into the vertical distance (taken in feet or inches) of the force, or the line along which it acts, from that point. The moment is, therefore, spoken of as so many foot-pounds, or inch-pounds, as the case may be: it is a compound quantity.

4. The moment of a force may also be taken about a line or plane. Thus, in Figure 1, the moment of the force P about the point A is $P\,l$.

It is evident that P will rotate about A, always remaining at the distance l from it, unless a counterforce is applied, equal and opposite in direction to P. This counterforce would act as shown in Figure 2. It will be noticed that P, in Figure 1, rotates in the direction taken by the hands of a clock; and that P' (Fig. 2) turns in the opposite direction. To distinguish between these two the moment in Figure 1 is said to be a positive quantity, $+ P\,l$; and the other is called $- P\,l$.

5. This is very important; and the reader, to be able to readily understand the following discussion, or, in fact, any problem in statics, must train himself to see at a glance whether a moment is positive or negative, or, as may be said, whether it is right-turning or left-turning.

6. In the case of a beam, as well as of structures of a more complicated nature, part of the exterior forces acting upon them are given, and are then known as *loads*, while others, which are to be found, are called *reactions*.

7. When a load acts upon an object continually, it is known as a *static*, or *dead load*; when it acts only occasionally, it is known as a *live*, or *moving load*. Thus the weight of a roof-truss would be the static load, while the wind or snow would be the live-load on it; in the case of a bridge, the whole weight of the construction would be the dead-load, and a crowd of people, vehicles, or a train would be the live or moving load; and so on.

8. A load acting only on one point is called a *concentrated load*, to distinguish it from a *uniformly distributed load*, which acts on a line, or an area.

9. When external forces are applied to a body they cause a *strain* of that body, or, rather, of the molecules of which it is composed.

These molecules resist the tendency to separation caused by this strain, and in so doing give rise to an interior force known as *stress*.

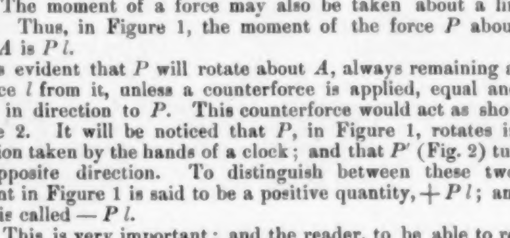


Fig. 3.

That is, stress is caused by and resists strain. Stress results from forces in the body, strain from forces outside of the body. The widest differences exist among the definitions of strain and stress as given by the several authorities. Some call strain the *distortion* of the body caused by the application of external forces; it ought, therefore, to be measured in units of length and not weight; this is, however, commonly not done.

10. We have now defined a sufficient number of preliminary terms to begin to study the influence of a uniformly distributed load on a beam freely supported at both ends; we shall take the beam $A\,B$ (Fig. 3) with a span of l feet and a load of p lbs. per foot, or a whole load of $p\,l = P$ lbs. Let us assume the load P large enough to cause the beam to deflect, as shown; in so doing, the molecules composing the beam must have been forced to change their position. This is really the case: strains and stresses have been at work; the molecules of the upper half of the beam have been crowded together, while those of the lower half have been separated, so to speak. Or, the load has caused a *compressive strain*, or simply *compression* — resisted by a *compressive stress* in the upper half of the beam, and a *tensile strain*, or simply *tension*, resisted by a *tensile stress* in the lower half.

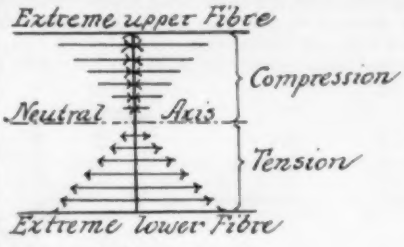


Fig 4.

As soon as these compressive and tensile strains grow greater than their respective stresses, the beam will break or fail.

11. If we were to take a cross-section of the beam, and examine the stresses existing there more closely, we should find the compressive stress greatest at the *extreme* upper edge or *fibre* of the beam, gradually growing less as we neared the centre, at which we should find no stress whatever; below the centre we should find a tensile stress, growing gradually as we neared the *extreme* lower *fibre*, at which we should find it to be a maximum. We have attempted to show this in Figure 4, indicating the cross-section by a vertical line, the compressive stresses by forces directed toward the section, and the tensile stresses as forces pulling away from it. At the centre, or rather in the plane passing through the centre parallel to the extreme fibres, and regarded as of infinitesimal thickness, there is neither tension nor compression. This plane is called the *neutral plane;* and its line of intersection with the plane of any cross-section taken through the beam is called the *neutral axis* of that cross-section.

The neutral axis of a cross-section may lie in any direction; but it is usually assumed through the *centre of gravity* of the cross-section, and separates all the fibres in compression from all those in tension.

12. It has been found that the amount of the stresses of the different fibres varies directly as their distance from the neutral axis; the stress in the fibres farthest from the neutral axis being greatest, the stress at the neutral axis itself being naught.

In designing a cross-section, we need, therefore, only be sure that the extreme fibres will be able to resist the given strain, there being no doubt about the other fibres in that case, as they are strained less, while their resistance is just as great as that of the extreme fibres.

It will occur to the reader that for this reason iron beams are rolled in the shape of an I; thereby putting the greatest amount of metal just where it is most needed, *i. e.*, at the top and bottom.

13. In the foregoing paragraph we had occasion to refer to the *centre-of-gravity;* this, as the reader undoubtedly knows, is that point of a body at which its entire "weight" seems concentrated; or, if the body is supported at this point, or along a line passing through it, no matter what its position otherwise may be, it will balance or be in equilibrium, so long as it is only acted upon by the force of gravity.

In another chapter we shall again take up the neutral axis, together with other things of a similar nature; the above will be sufficient for our present purpose.

14. Returning to our uniformly loaded beam $A\,B$, we shall now take the moments of all the external forces — on one side of a cross-section — about the neutral axis. The algebraic sum of these moments is known as the *bending-moment* of the beam. It varies

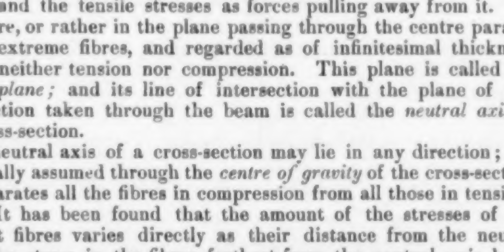


Fig. 5.

with the position of the cross-section, according to a law which can be easily deduced.

15. The exterior forces acting upon the beam are the load $p\,l$ (p pounds per foot, the span being l feet), and the reactions A and B (See § 6).

The reader knows that a force applied to any body causes a counterforce, or *reaction*, in that body. If the body is to remain in equilibrium, *i. e.*, if its "state of motion" (considering "rest" as one state) is not to be changed, this reaction must necessarily be equal and opposite in direction to the force applied. In structures, the direction and position of the reactions vary with the manner of loading and supporting.

In the case under consideration, the beam being supported freely, that is, not hinged or fastened in any way to its abutments; the

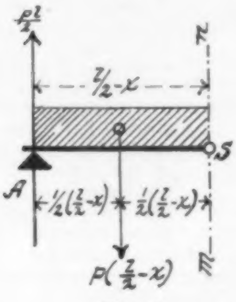


Fig. 6.

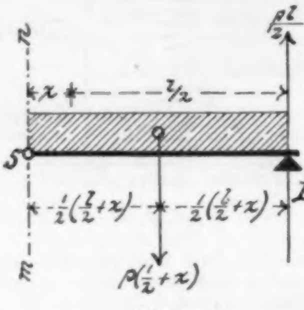


Fig 7.

reactions at A and B will be vertical and each will be equal to one-half of the entire load $\left(\frac{p\,l}{2}\right)$.

16. Let us assume a section, $m - n$, at the point s of the beam (Fig. 5), at a distance x from the centre, and regard only the left portion of the beam, $A\,s$ (Fig. 6). We shall now take the moments of all the external forces acting upon this portion about the point s, calling their algebraic sum M.

17. We have, first, the reaction $\frac{p\,l}{2}$, rotating about s at the distance $\frac{l}{2} - x$ in the direction of the hands of a clock; its moment is, therefore: $+\frac{p\,l}{2}\left(\frac{l}{2} - x\right)$.

Then we have the load $p\left(\frac{l}{2} - x\right)$, acting upon the beam at a distance $\frac{1}{2}\left(\frac{l}{2} - x\right)$ from s and turning in a direction opposite to that of the foregoing; its moment about s is therefore:

$$-p\left(\frac{l}{2} - x\right)\frac{1}{2}\left(\frac{l}{2} - x\right), \text{ which equals} - \frac{1}{2}p\left(\frac{l}{2} - x\right)^2$$

Therefore, the entire moment is:

$$M = \frac{p\,l}{2}\left(\frac{l}{2} - x\right) - \frac{p}{2}\left(\frac{l}{2} - x\right)^2$$

By performing the operations indicated, this becomes

$$M = \frac{p\,l^2}{4} - \frac{p\,l\,x}{2} - \frac{p\,l^2}{8} + \frac{p\,l\,x}{2} - \frac{p\,x^2}{2}$$

which can be simplified to

$$M = \tfrac{1}{8}p\,l^2 - \tfrac{1}{2}p\,x^2. \qquad (1)$$

18. This, then, is the equation which gives the bending-moment at a point any distance, x, from the centre of the beam.

It is evident that M will be a maximum as soon as x becomes zero, for then the last term of the right-hand member of the equation vanishes, which becomes

$$M = \tfrac{1}{8}p\,l^2 \qquad (2)$$

This is the equation of the maximum bending-moment; it occurs at the centre of the beam, for there $x = 0$.

On the other hand, M becomes a minimum when $x = \frac{1}{2}l$, for then the right-hand member of the equation vanishes, which shows that the bending-moments at the points of support are naught.

It will be well to insert here that in all of these equations p is the load in pounds per foot, while l is the span in *inches*, so that M is expressed in inch-pounds. The reason for taking l in inches instead of feet will become evident farther on.

19. It was said above, that the bending-moment is equal to the moments taken on *one* side of any cross-section; we have just taken them on the left side of the section $m - n$; let us now take them on the right side, and compare results.

We have (Fig. 7) first: the moment of the load (taken about the point s) equal to $+p\left(\frac{l}{2} + x\right)\frac{1}{2}\left(\frac{l}{2} + x\right)$ (for this moment is right-turning). Second: the moment of the reaction at B equals $-\frac{p\,l}{2}\left(\frac{l}{2} + x\right)$, because it is left-turning.

This gives us the bending-moment

$$M' = p\left(\frac{l}{2} + x\right)\frac{1}{2}\left(\frac{l}{2} + x\right) - \frac{p\,l}{2}\left(\frac{l}{2} + x\right).$$

$$= \frac{p\,l^2}{8} + \frac{p\,l\,x}{2} + \frac{p\,x^2}{2} - \frac{p\,l^2}{4} - \frac{p\,l\,x}{2}$$

$$M' = \tfrac{1}{2}p\,x^2 - \tfrac{1}{8}p\,l^2 \qquad (3)$$

20. Comparing (1) and (3) we find that

$$M = -M',$$

or, if the beam is to be in equilibrium, the sum of the moments on one side of any section is equal and opposite in sign to the sum on the other side.

The bending-moment is usually considered positive when it tends to bend the beam downward, and negative when the beam is convex above, which case rarely occurs in simple beams.

21. Equation (1), being of the second degree, is evidently the equation of some curve; we can, therefore, represent the bending-moment graphically. For this purpose let us write Equation (1) as follows:

$$M = \tfrac{1}{2}p\left(\frac{l^2}{4} - x^2\right)$$

Because the product of the sum and difference of two numbers is equal to the difference of their squares, this may be written:

$$M = \tfrac{1}{2}p\left(\frac{l}{2} + x\right)\left(\frac{l}{2} - x\right) \qquad (4)$$

Now $\frac{l}{2} + x$ and $\frac{l}{2} - x$ are evidently the two segments into which the beam is divided by the cross-section. If, for the sake of simplicity, we place $\frac{l}{2} + x = a$, and $\frac{l}{2} - x = b$, $(a + b = l$, the entire span$)$ Equation (4) becomes

$$M = \tfrac{1}{2}p\,a\,b \qquad (5)$$

22. The reader sees that this is really only another form of Equation (1); in fact, it could have been derived in the same way. It expresses in terms of the segments of the beam what Equation (1) expressed in terms of x, the distance of the cross-section from the centre.

Equation (5) expresses the following law:

For a uniform load the bending-moment at any section through a beam is equal to the product of $\frac{1}{2}$ the load per foot multiplied by the segments into which the beam is divided by that section.

23. From Equation (5) it is apparent that we can represent the bending-moment (for any section dividing the beam into the segments a and b) by the ordinate $E\,H$ (Fig. 8) of a parabola $A\,H\,C\,B$, whose maximum ordinate $D\,C$ is $\frac{1}{8}p\,l^2$.

That is, if we make $D\,C = \frac{1}{8}p\,l^2$, connect A and C, draw $E\,H$ perpendicular to $A\,B$ at E, and intersecting $A\,C$ at F, then $F\,G$ parallel to $A\,B$ until it intersects a vertical through A at G, and lastly, connect G and C; this line will determine a point H of the parabola on the vertical through E, for

$E\,F : D\,C :: a : \frac{1}{2}l$

(Δ's $A\,E\,F$ and $A\,D\,C$ being similar)

$$\text{or } E\,F = \frac{\frac{1}{8}p\,l^2\,a}{\frac{1}{2}l} = \tfrac{1}{4}p\,l\,a$$

Also $F\,H : A\,G :: b - \frac{1}{2}l : \frac{1}{2}l$

(Δ's $C\,F\,H$ and $C\,A\,G$ being similar),

$$\text{or } F\,H = A\,G\frac{b - \frac{1}{2}l}{\frac{1}{2}l} = A\,G\,\frac{2\,b}{l} - 1$$

And $A\,G = E\,F$; therefore, $F\,H = \left(\frac{2\,b}{l} - 1\right)\frac{1}{4}p\,l\,a$

But $E\,H = E\,F + F\,H$

$$= \tfrac{1}{4}p\,l\,a\left(1 + \frac{2\,b}{l} - 1\right)$$

$$= \tfrac{1}{2}p\,a\,b.$$

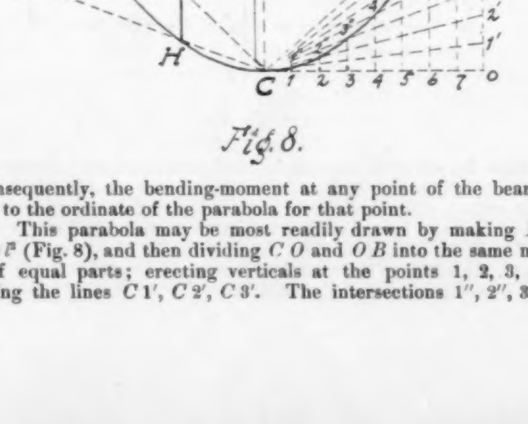


Fig. 8.

Consequently, the bending-moment at any point of the beam is equal to the ordinate of the parabola for that point.

24. This parabola may be most readily drawn by making $D\,C = \frac{1}{8}p\,l^2$ (Fig. 8), and then dividing $C\,O$ and $O\,B$ into the same number of equal parts; erecting verticals at the points 1, 2, 3, and drawing the lines $C\,1'$, $C\,2'$, $C\,3'$. The intersections 1″, 2″, 3″ of

the respective lines are points of the parabola. If a sufficient number of points is thus determined, the parabola may be drawn through them by means of a French curve.

25. By placing $P = p\,l$, Equation (2) becomes

$$M = \frac{P\,l}{8}. \qquad (6)$$

The reader will de well to memorize this equation, as it is the one most frequently made use of in practical work. It may be expressed as follows:

For a uniformly distributed load, the maximum bending-moment of a beam is equal to $\frac{1}{8}$ of the product of the entire load multiplied by the span.

The span l is to be taken in inches and the load P in pounds, so that M will be expressed in inch-pounds.

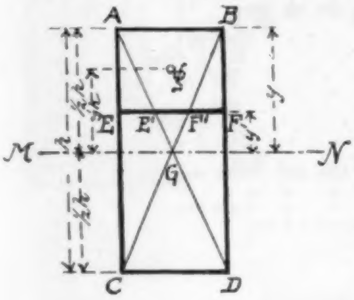


Fig. 9.

26. Having found in the bending-moment an expression for the amount of strain, we must now proceed to find a similar expression for the resisting stresses.

This expression is very appropriately called the *moment-of-resistance.*

27. It has been pointed out that the stresses are greatest at the extreme fibres of a cross-section, and diminish regularly as we near the neutral axis, at which they are equal to zero; or, the stress in any fibre varies directly with its distance from the neutral axis. Therefore, if $A\,B\,C\,D$ (Fig. 9) represents the cross-section of our beam, and $M\,N$, the neutral axis, passing through the centre-of-gravity G, parallel to the extreme fibres $A\,B$, $C\,D$, the stress in the fibre $A\,B$ would be to the stress in the fibre $E\,F$ as y (the distance of $A\,B$ from the neutral axis) is to y' (the distance of $E\,F$ from the neutral axis).

If we let the length $A\,B$ represent the amount of the stress in the fibre $A\,B$, then, by making use of a well-known property of similar triangles (that of their bases being to each other as their heights), we can represent the stress at $E\,F$ as that part of the line $E\,F$ included in the $\Delta\ A\,B\,G$, or $E'\,F'$.

For $A\,B : E'\,F' :: y : y'$

And stress $A\,B$: stress $E\,F :: y : y'$.

But stress $A\,B = A\,B$; therefore, stress $E\,F = E'\,F'$.

28. And the moment of the stress on any fibre of the part $A\,B\,M\,N$ (assuming this stress as a force acting vertically to the plane of the cross-section, for a reason to be subsequently given), as for instance, that of the fibre $E\,F$, about $M\,N$ will be equal to the product of, not $E\,F$, but its corresponding amount $E'\,F'$ in the Δ $A\,B\,G$, multiplied by its distance y' from the neutral axis, $M\,N$.

Therefore, to get the moment of the entire compressive stress about the neutral axis, we assume that entire stress to be concentrated at the centre-of-gravity of the Δ $A\,B\,G$, g, whose distance from $M\,N$, if the height of the whole cross-section equals h, will be equal to $\frac{2}{3}$ of $\frac{1}{2}\,h$ or $\frac{1}{3}\,h$ (the centre-of-gravity of a Δ being distant two-thirds of its height from the apex).

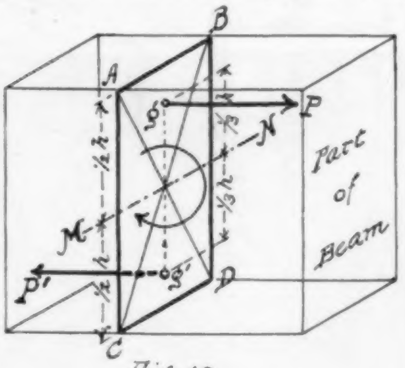


Fig 10.

29. Inserting for P (the sum of all the compressive stresses), in Figure 10, which is an isometric view of the cross-section, its value $\frac{1}{2}\,(\frac{1}{2}\,h\,b)\,s$, which is the area of the Δ $A\,B\,G$ multiplied by the allowed stress of s pounds per square inch, we get for the moment of all the compressive stresses about $M\,N$ the following:

$$R_{\text{comp.}} = \tfrac{1}{3}\,h\,\tfrac{1}{2}\,(\tfrac{1}{2}\,h\,b)\,s = \tfrac{1}{12}\,h^2\,b\,s.$$

Similarly, we get for the moment of all the tensile stresses about $M\,N$,

$$R_{\text{tens.}} = \tfrac{1}{3}\,h\,\tfrac{1}{2}\,(\tfrac{1}{2}\,h\,b)\,s = \tfrac{1}{12}\,h^2\,b\,s.$$

As both of the moments turn in the same direction, as indicated by the arrow (Fig. 10), we add them together, and get for their sum

$$R_{\text{comp.}} + R_{\text{tens.}} = R' = \tfrac{1}{6}\,b\,h^2\,s \qquad (7)$$

The s, being a variable quantity, in every case dependent upon the strength of the material to be used, is usually eliminated from the equation, and the latter written,

$$R = \tfrac{1}{6}\,b\,h^2 \qquad (8)$$

30. This R is then called the moment-of-resistance, although that term applies more properly to R' as given by Equation (7). It will, however, be best for us to follow the usual practice and call R the moment-of-resistance, understanding it to be defined by the equation,

$$R = \frac{R'}{s} \qquad (9)$$

31. From what has been said above, it follows that if the beam is not to fail, the following relation must hold good:

$M = R'$, or

$M = s\,R$, or

$$\frac{M}{s} = R \qquad (10)$$

In which

M = maximum bending-moment in inch-pounds, as given by Equations (2) or (6).

S = allowed maximum stress on extreme fibres in pounds per square inch.

R = moment-of-resistance of cross-section in inches.

32. Equation (10) may be said to represent all the operations necessary to perform in determining the required cross-section of a beam for a given load and span. The bending-moment must be found; this, divided by the assumed safe fibre stress, gives the required moment-of-resistance, from which, if one of the dimensions of the cross-section be adopted — provided this be rectangular in shape — the other may readily be found.

Of course, for iron or steel beams, channels, etc., the R has been calculated for all possible shapes, and need simply be taken from the hand-books of the iron companies.

Of this we shall, however, speak more fully in the next chapter.

O. F. SEMSCH.

[To be continued.]

HISTORY OF THE UNITED STATES CAPITOL.[1]—IX.

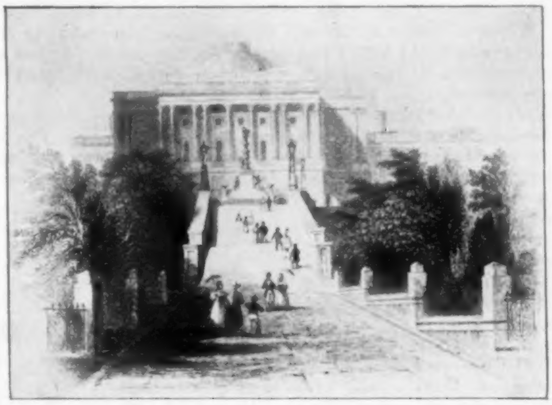


Fig. 58. View of Exterior Stairs and Western Portico. Bulfinch, Architect.

THE old Capitol was situated in a park of twenty-two and one-half acres (Fig. 60), enclosed by an iron railing. There were nine entrances to the grounds, two each from the north and south for carriages, two on the east and three on the west for

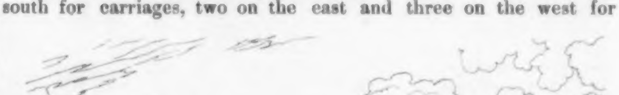


Fig. 59. From a Drawing made by George Strickland, Draughtsman for Bulfinch.

pedestrians. The western entrances at the foot of the hill were flanked by two ornamental gate or watch houses. The fence was of

[1] Continued from No. 1087, page 29.

iron, taller than the head of an ordinary man, firmly set in an Aquia Creek sandstone coping, which covered a low wall.

On entering the grounds by the western gates, passing by a fountain, one ascended two flights of steps to the "Grand Terrace" (Fig. 58).

Upon the first terrace was the Naval Monument, erected to those who fell in the Battle of Tripoli. This was a white marble column, decorated with beaks of vessels and anchors grouped in various positions. On and around the column and base were allegorical figures. (See Fig. 63.) On the socle were the names of those who fell in the battle: Somers, Caldwell, Decatur, Wadsworth, Dorsey and Israel. This monument rose out of a basin of "water supplied from the contiguous fountain." This monument is now at Annapolis.

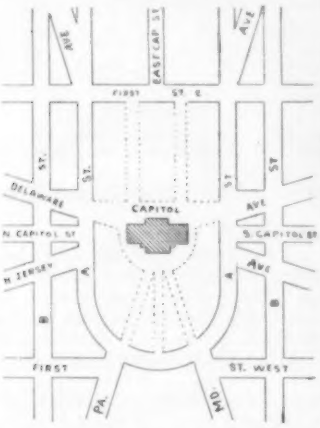


Fig. 60. Old Capitol Grounds, as completed in 1830.

There was an entrance into the sub-basement of the Capitol from the first terrace. Under the archway leading into this entrance was a marble fountain with water from Smith's spring.

The second flight of steps landed on the main terrace, a few feet below the level of the basement entrance.

The eastern entrance, according to Mills, had spacious gravel walks, through a "dense verdant enclosure of beautiful shrubs and trees circumscribed by an iron Palisade."

The old Capitol building covered 67,220 square feet of ground. The front was 351 feet, 4 inches long. The depth of the wings was 131 feet, 6 inches; the central eastern projection, including the steps, 86 feet (Fig. 59); the western projection, 83 feet (Fig. 58); the height of wings to the top of balustrade, 70 feet; to top of dome in centre, 145 feet. The portico on the east is 160 feet wide, composed of a double row of Corinthian columns, elevated on a rustic basement.

With the exception of the dome, the central portion of the present Capitol is the old building unchanged on the exterior. The basement of rusticated stonework is surmounted by the Corinthian order. Between the pilasters and columns two stories are grouped. The top of the building is surrounded by a stone balustrade. Over each wing is a low dome surmounted by a cupola. The central dome was considered high, because it reached a greater altitude than the domes shown on the plans of Thornton and Latrobe, Bulfinch having materially increased its height. The whole exterior walls and porticos were of Aquia Creek sandstone, painted white. The roof of the building, including the dome, was of wood covered with copper. The sub-basement, under the western portion of the central building, was utilized for committee-rooms. The north side was used by the Senate and the south side by the House (Fig. 62). On the east of the sub-basement were the store-rooms and "Refectory," or restaurant.

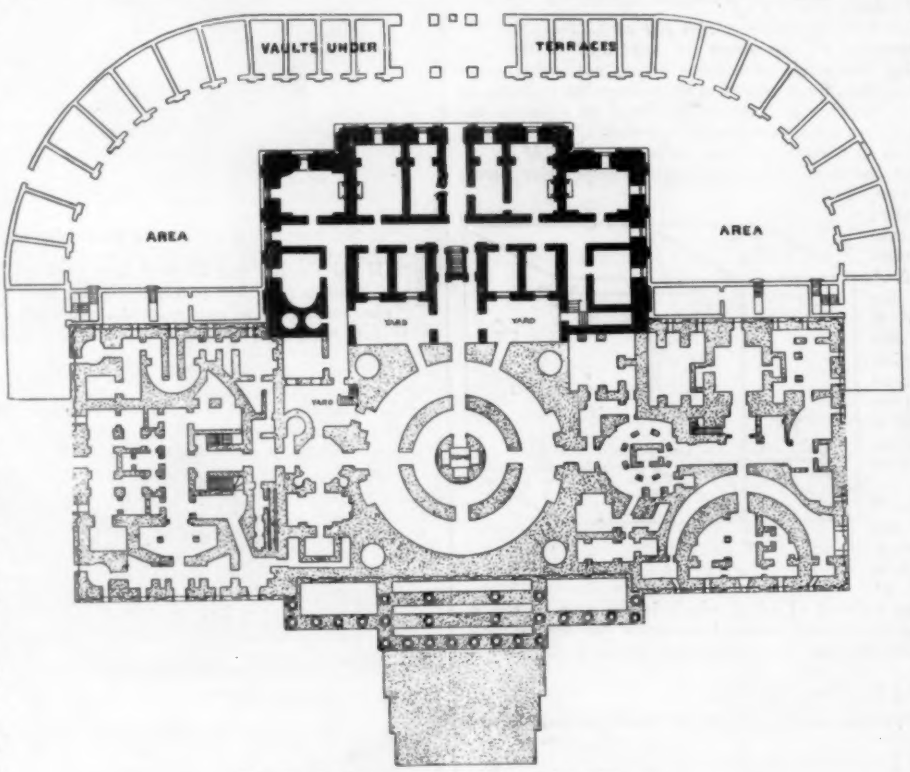


Fig. 62. Sub-basement: black portion used for Office-rooms.

From the western entrance of the sub-basement, a stairway leads to the basement story above. On both sides of this stairway a hall leads to the chamber prepared to receive the sarcophagus of George Washington, beneath the centre of the crypt. (See Fig. 62, plan of sub-basement.)

The basement story (Fig. 61) was a few feet above the street level on the east and the same distance above the principal terrace on the west.

This floor of the Capitol had several entrances on the south, north, east and west, where they would afford readiest access to the different portions of the building. An arcaded passageway ran under the principal eastern portion. At the north and south ends of this passageway were the vestibule entrances leading to the main stairways of the Senate and House. (Fig. 64.)

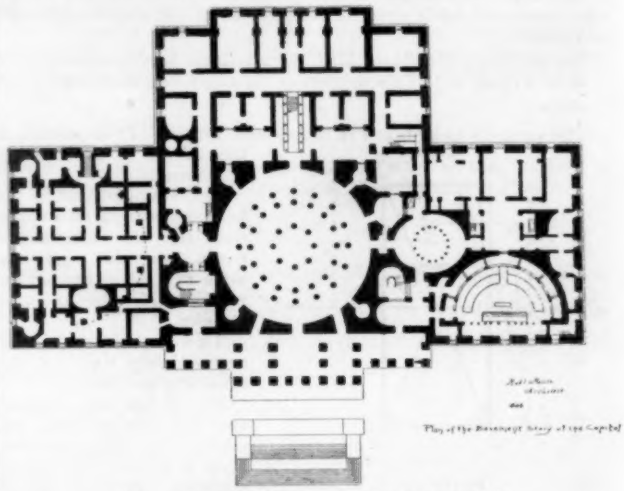


Fig. 61. Basement Plan from Drawing by Robert Mills.

The north half of the Capitol, except on the third floor and Supreme-Court room, were appropriated to the use of the Senate and its committees, while the south part was appropriated to the House and its committees, clerks and other officials.

The central portion of the basement is the crypt, a circular room beneath the rotunda. The floor of the apartment above is supported on groined arches, resting upon Doric columns, modelled after those of the Temple of Pæstum (Fig. 66). Leading north from the crypt is a passageway to a central hall, lighted from above. This was originally intended for the stairway. The brickwork surrounding it has remained through all the changes.

Latrobe removed the stairway which led to the Senate above and placed it in the hall to the east, in a particularly out-of-the-way position, where only those familiar with the plan can find it. From this confined hall one doorway led into the Supreme Court, the other into the Marshall's Office.

On the west side of the elliptical passageway was a door leading to the Law Library. Farther north, on the west side, were the entrances to the apartments of the Clerk of the Supreme Court. Near the north entrance were the rooms of the Attorney-General and Judges, west and east of the hall, respectively.

The entrance to the court-room was from the Senate stairway hall. This room is semicircular in plan with an arched recess on the west, through which an arcaded passageway ran, and on which the groined-arch ceiling, which covered the whole room, rested. On the east of the room is a colonnade, through which the chamber is lighted (Fig. 65). At the present time the room is used as the Supreme-Court Library.

The columns were modelled on the Doric order. The construction is particularly massive, as the first domed ceiling of the room failed for want of proper abutments. Complaints were made of the

Fig. 63. The Tripoli Monument, Annapolis, Md.

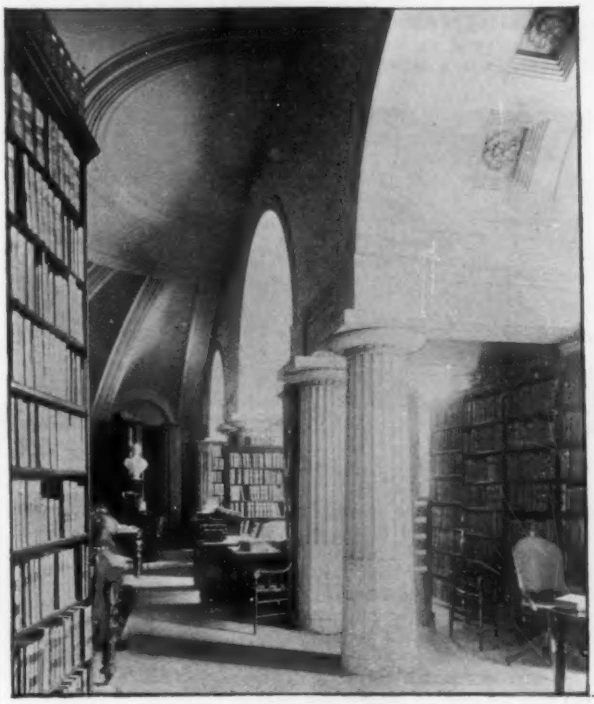


Fig. 65. Old Supreme-Court Room; Present Supreme-Court Library.

lack of light and ventilation in this room. The floor, as late as 1847, was below the general level. In the tympanum of the west arch is a figure of "Justice" (Fig. 67).

On the south of the crypt a passageway leads directly to the southern entrance. The stairway to House of Representatives is just to the west of this hall; the space was occupied by committee-rooms. A furnace-room is below them for heating the house.

GLENN BROWN.

(To be continued.)

Fig. 64. Vestibule of Senate Basement.

Fig. 66. Crypt.

ALUMINIUM GLASS. — A French glass expert, named Appert, has made experiments showing that glass modified by the introduction of 7 or 8 per cent of aluminium is more solid, less changeable, and more elastic than ordinary glass. — *N. Y. Evening Post.*

PATALIPUTRA, THE INDIAN TROY.

AT last the ruins of the Indian Troy, deeply buried in the débris of over twenty-two centuries, are likely soon to see the light. Pataliputra, the "Palibothra" of the Greeks, the "city of sweet-scented flowers," so famous in ancient Indian legend and romance, is perhaps most widely known as the capital of Asoka, the greatest of Indian emperors, and the most lavish devotee the world has ever seen. He covered his mighty kingdom from Afghanistan to the Deccan, from Nepal to Gujerat, with countless Buddhist monuments and buildings of vast size. His stupendous stupas, or mounds, of solid masonry, to enshrine Buddha's relics, or to mark some sacred spot, are found all over India, and are almost like Egyptian pyramids in size. His colossal "edict pillars," single shafts of stone over forty feet in length and beautifully polished and sculptured, still excite the admiration and wonder of all who see them. How magnificent, then, must have been the capital of this great Hindoo king, who was the ally of the Greek kings, Antiochus of Syria, Ptolemy of Egypt, Antigonos of Macedon, Magnas of Cyrene and Alexander of Epirus.

It was already a splendid city in the fourth century B. C., in the time of his grandfather, Chandragupta, the Greek Sandracottus, as we learn from the glowing descriptions of Megasthenes, the ambassador of the successor of Alexander the Great. At that time the buildings were all of wood, like the palaces and temples of Burmah in the present day. It is a matter of history, however, how Asoka found this capital of wood and left it of stone. But, before the dawn of our era, this great city had decayed with the fall of Asoka's dynasty and the smaller succeeding dynasties, and the transfer of capital elsewhere. In 400 A. D., the Chinese pilgrim Fa Hian reported that it lay deserted and in ruins. Since the Mohammedan invasion in the twelfth century A. D., the very site of this city was forgotten. It was known to be somewhere near the modern town of Patna, in

Fig. 67. "Justice," in Old Supreme Court.

Bengal; but most of the experts and others who had deliberately searched for it believed that it had been entirely washed away by the Ganges. Then it will be remembered that Surgeon Major Waddell, in 1892, during a flying visit to Patna, found that the leading landmarks of Asoka's capital still existed. He found several sculptured stones and images of the Asoka epoch lying on the surface or built into houses or walls, and these, together with the position of the old mounds, many of which still retain their ancient names, enabled him to fix with certainty the limits of Asoka's citadel, and also to indicate roughly the possible sites of particular buildings for exploratory excavations, without which, of course, no detailed identifications could be decisively attempted.

Unfortunately, most of the likely mounds now contain Mohammedan graves, for the Mohammedan invaders were wont to seize the highest mounds for their residence and burial grounds, and for centuries they have used these ruins as a quarry for their building material. Still, a beginning has now been made, and already at Patna, where five years ago no stones of the Asoka period were suspected to be, there may now be seen pieces of the well-known stone posts, the so-called Asoka railings, with their quaintly figured medallion-like bosses, by which Asoka perpetuated in stone the original wooden fences which surrounded the sacred Buddhist spots. And close by, one may see, about twelve feet below the present surface, parts of "the wooden walls" of Palibothra, with their marvellously well-preserved Sal timber, over twenty centuries old. — *Calcutta Englishman.*

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.*]

HOUSE OF BYRON NUGENT, ESQ., ST. LOUIS, MO. MR. W. A. SWASEY, ARCHITECT, ST. LOUIS, MO.

[Gelatine Print, issued with the International and Imperial Editions only.]

HOUSE OF G. W. POMROY, ESQ., HARTFORD, CONN. MR. F. R. COMSTOCK, ARCHITECT, HARTFORD, CONN.

THE exterior is clapboarded and painted an old red with ivory-white trimmings and moss-green roof. The underpinning is of Longmeadow stone, the chimneys being of buff brick, the one on the exterior having a foundation of cut-stone with a terra-cotta tablet at the second story. The dimensions of the house are 33′ x 63′. At the main entrance is a vestibule with a dome over it, the ceiling of which is handsomely decorated. The central dome is 6′ in diameter. Back of the main cornice and dome are incandescent electric-lights, 18″ apart.

THE ZEBU HOUSE: NATIONAL ZOÖLOGICAL PARK, WASHINGTON, D. C. MR. GLENN BROWN, ARCHITECT, WASHINGTON, D. C.

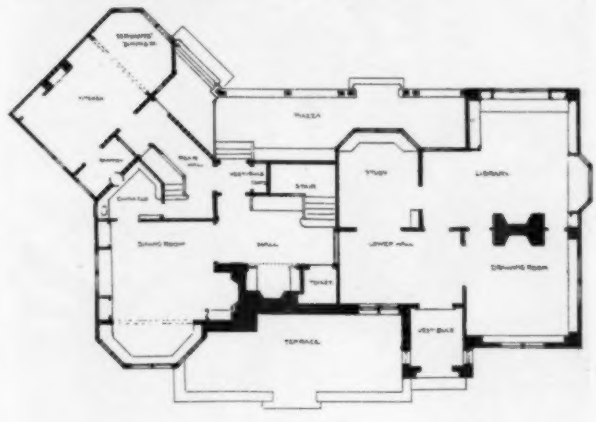
HOUSE FOR REV. F. E. SMILEY, DENVER, COL. MR. WM. COWE, ARCHITECT, DENVER, COL.

ALTERATIONS IN HOUSE OF MRS. M. B. HEWITT, CAMBRIDGE, N. Y. MR. F. R. COMSTOCK, ARCHITECT, HARTFORD, N. Y.

HOUSE OF C. S. ROBERTS, ESQ., BRATTLE STREET, CAMBRIDGE, MASS. MR. W. G. RANTOUL, ARCHITECT, BOSTON, MASS.

THE house is carried out inside somewhat in the style of the old English half-timber houses.

The hall and dining-room are wainscoted high, with quartered-oak and have deep recessed fireplaces with settles.



Plan of House for C. S. Roberts, Esq., Cambridge, Mass.

The library is wainscoted high with very dark cherry and has long bookcases.

The drawing-room is executed more in style of the time of King George III, in white-ivory finish.

WAREHOUSE OF THE J. F. DIETZ CO., CINCINNATI, O. MR. HARRY HOKE, ARCHITECT, CINCINNATI, O.

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MAIN ENTRANCE, SOUTH FRONT: LAW COURTS, COLOGNE, PRUSSIA.

SIDE ENTRANCE OF THE SAME.

WAITING-ROOM, SOUTH WING OF THE SAME.

PALAZZO FARNESE, CAPRAROLA, ITALY: PAINTINGS IN THE UPPER PART OF THE GRAND STAIRCASE, EXECUTED BY TEMPESTI.

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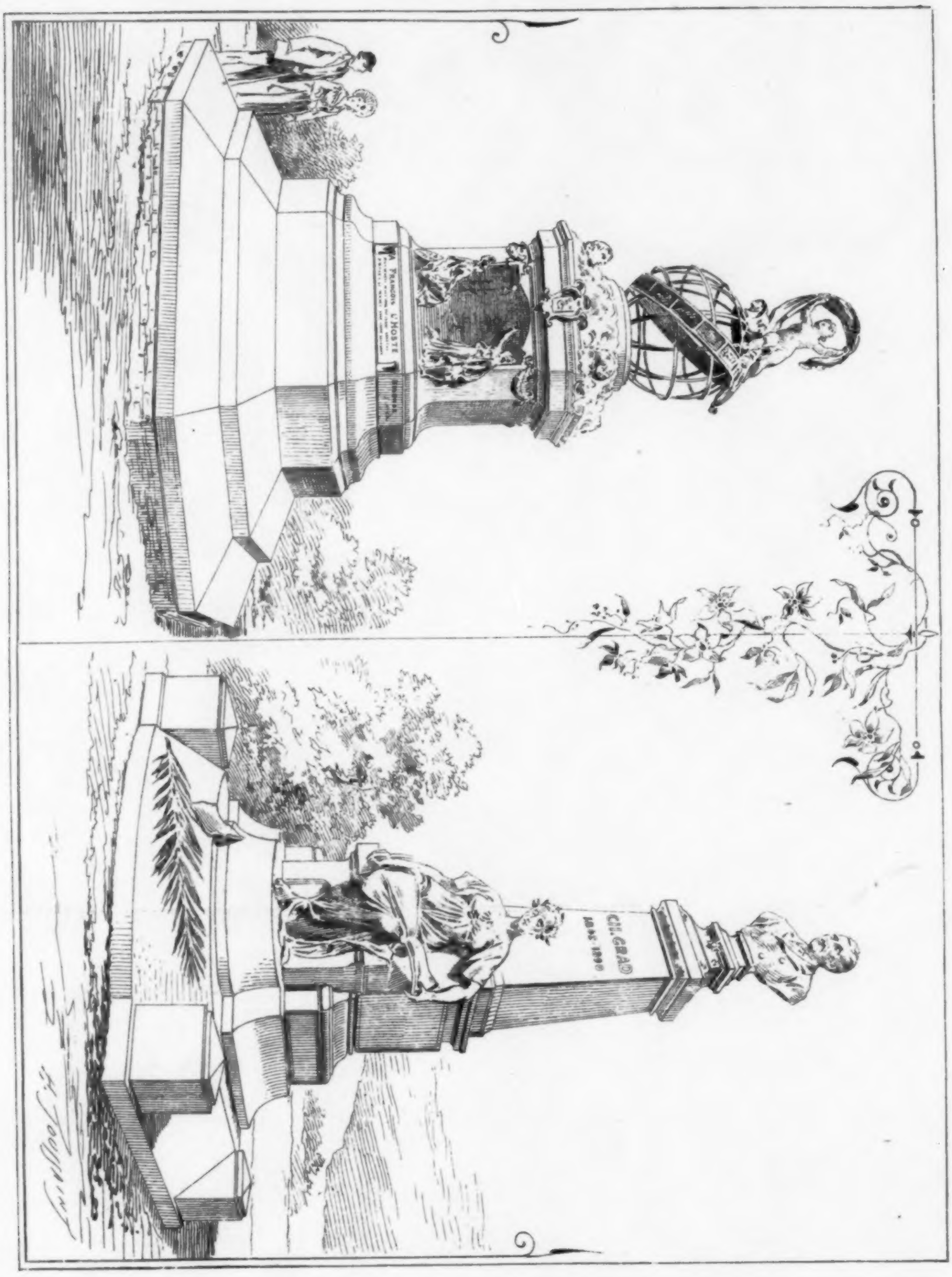
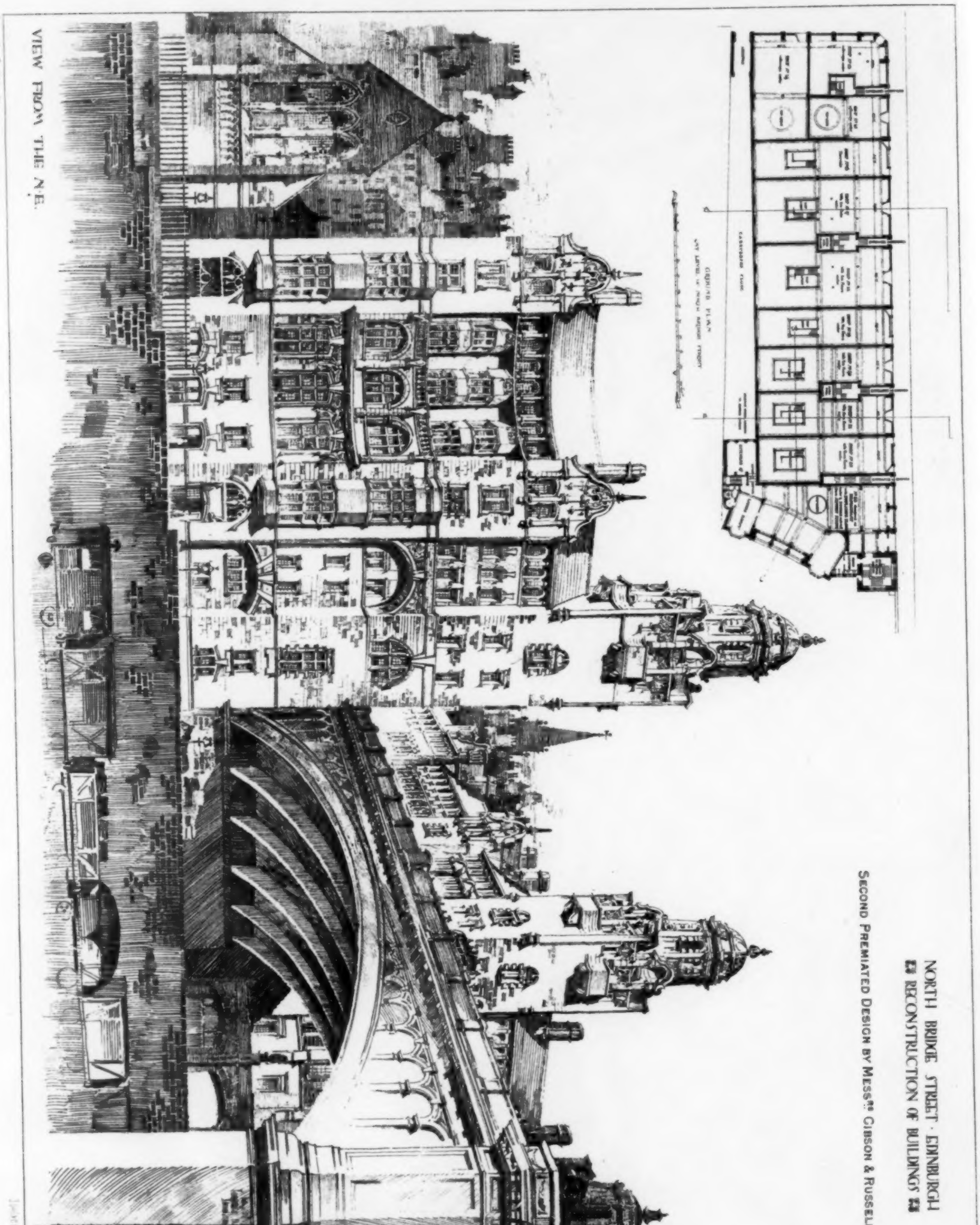


Monument de L Hoste
Arch. M Delemer

Monument de Grad
Arch M. Umbdenstock



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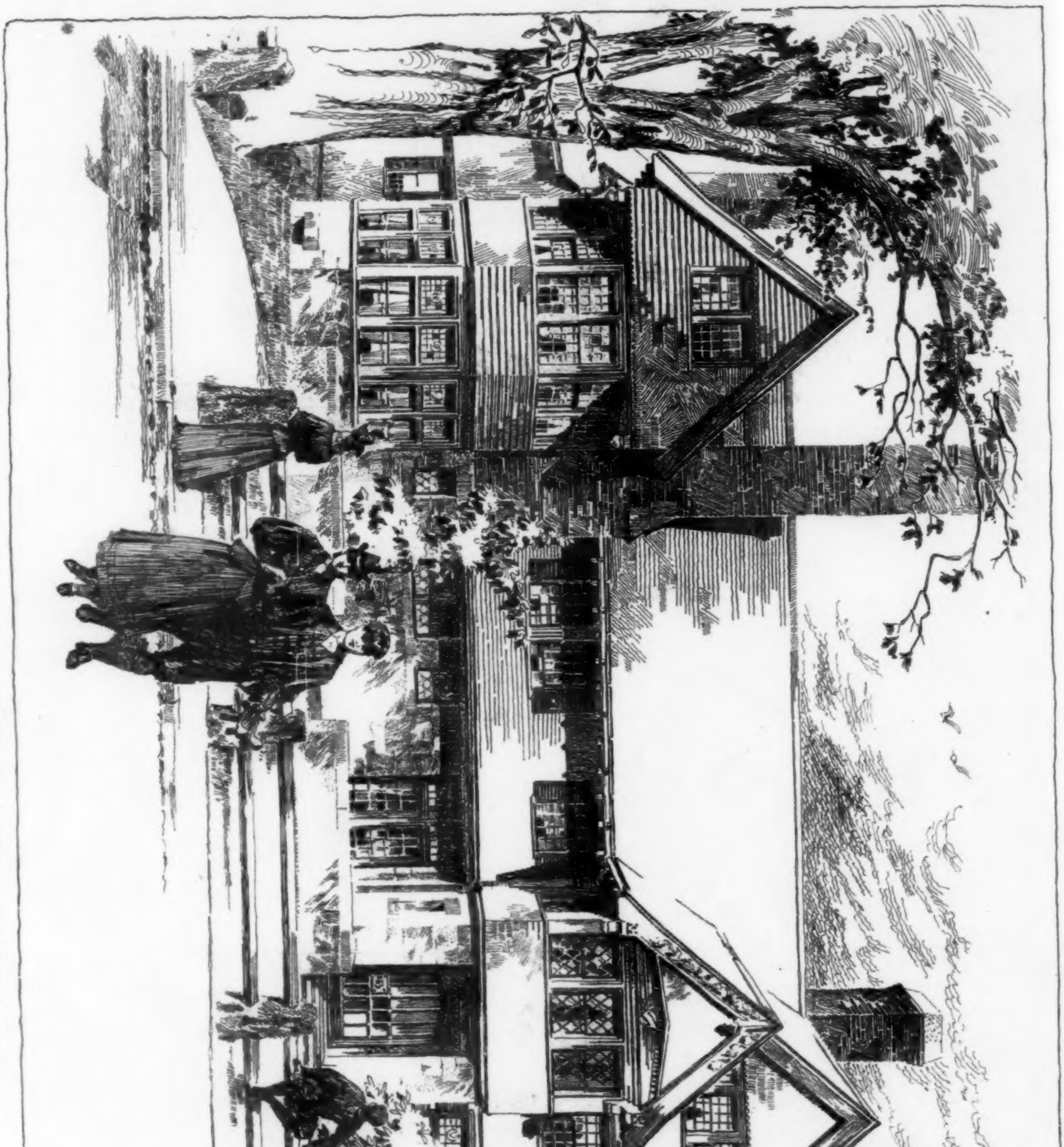

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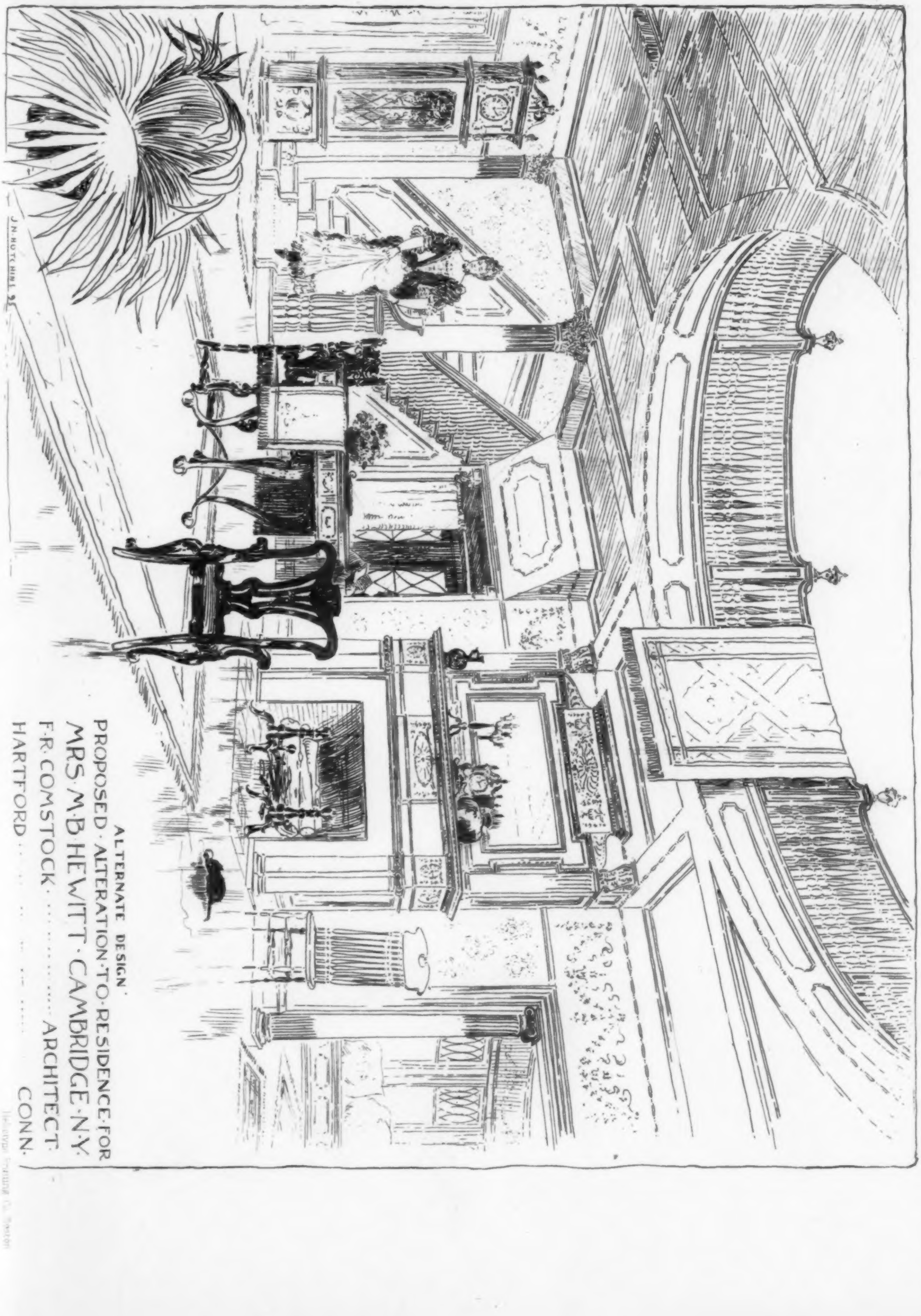

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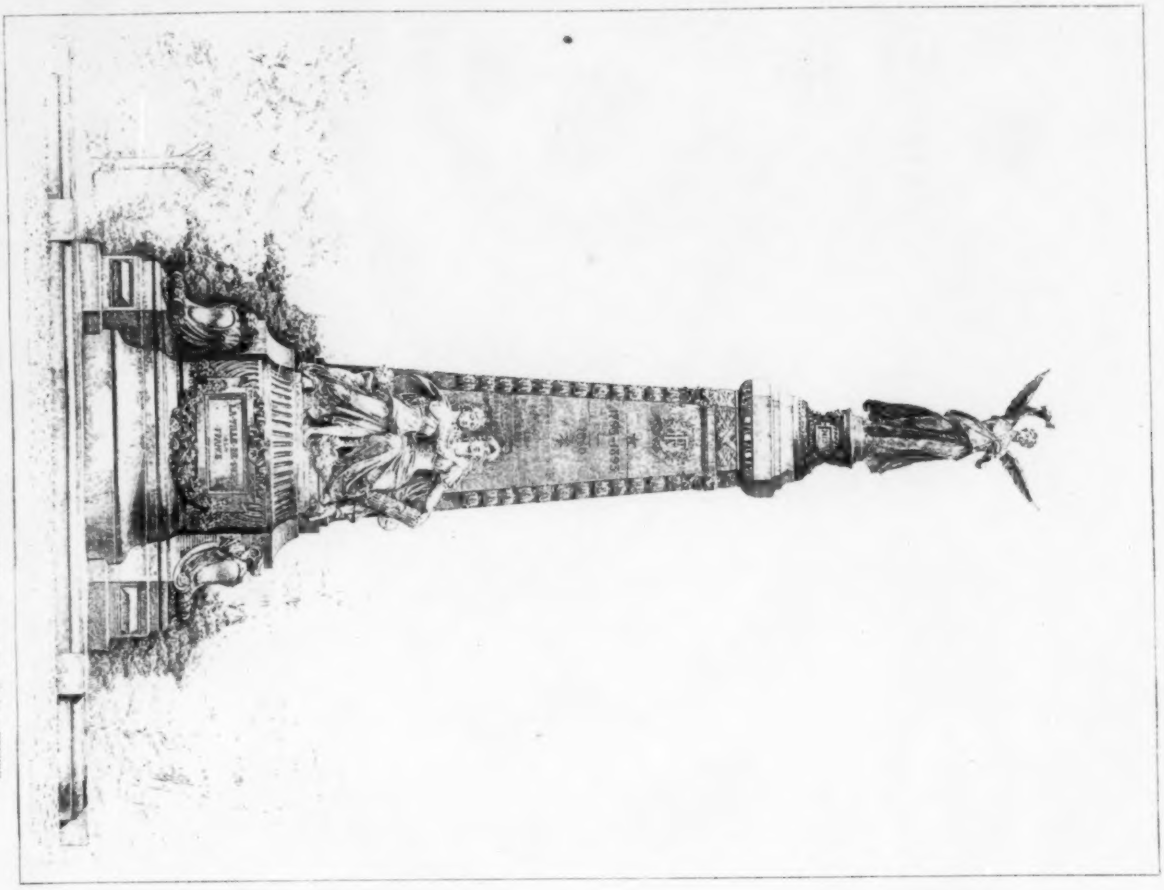

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Vue de la face principale.

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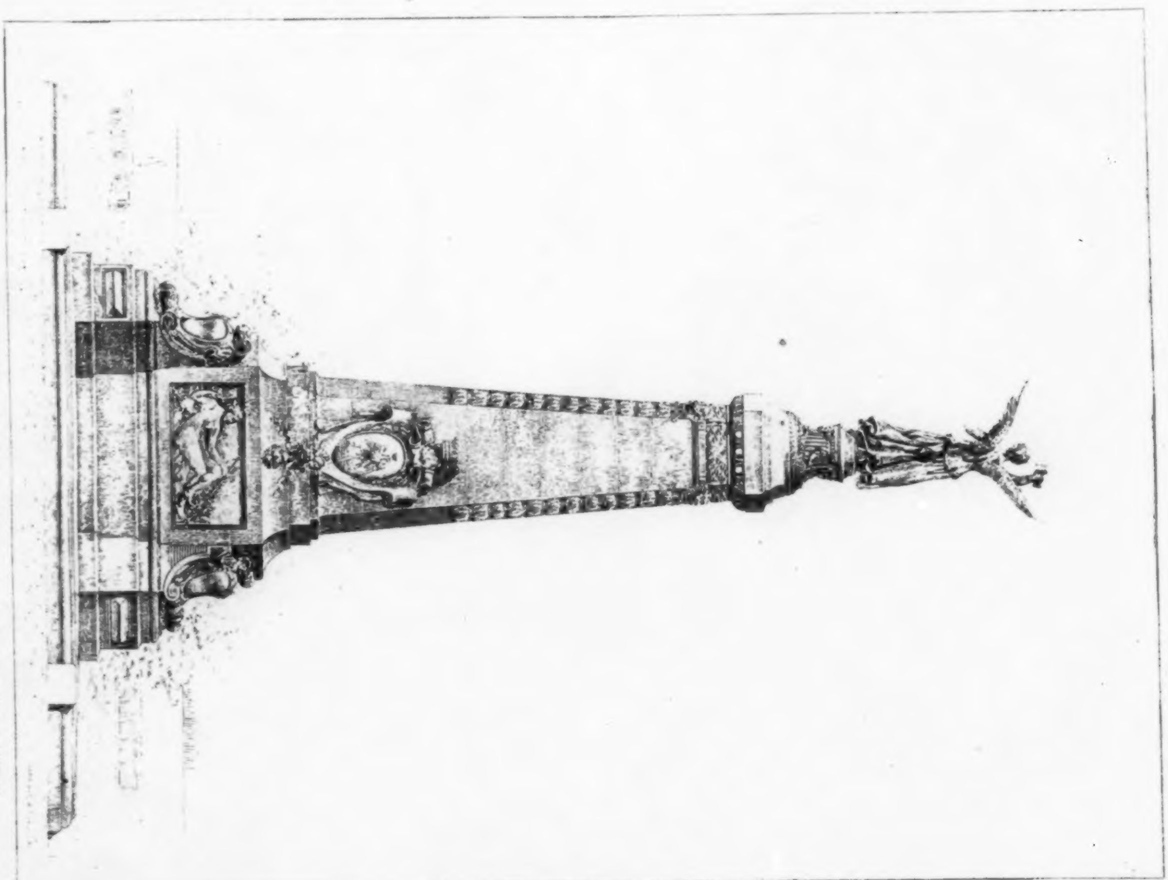

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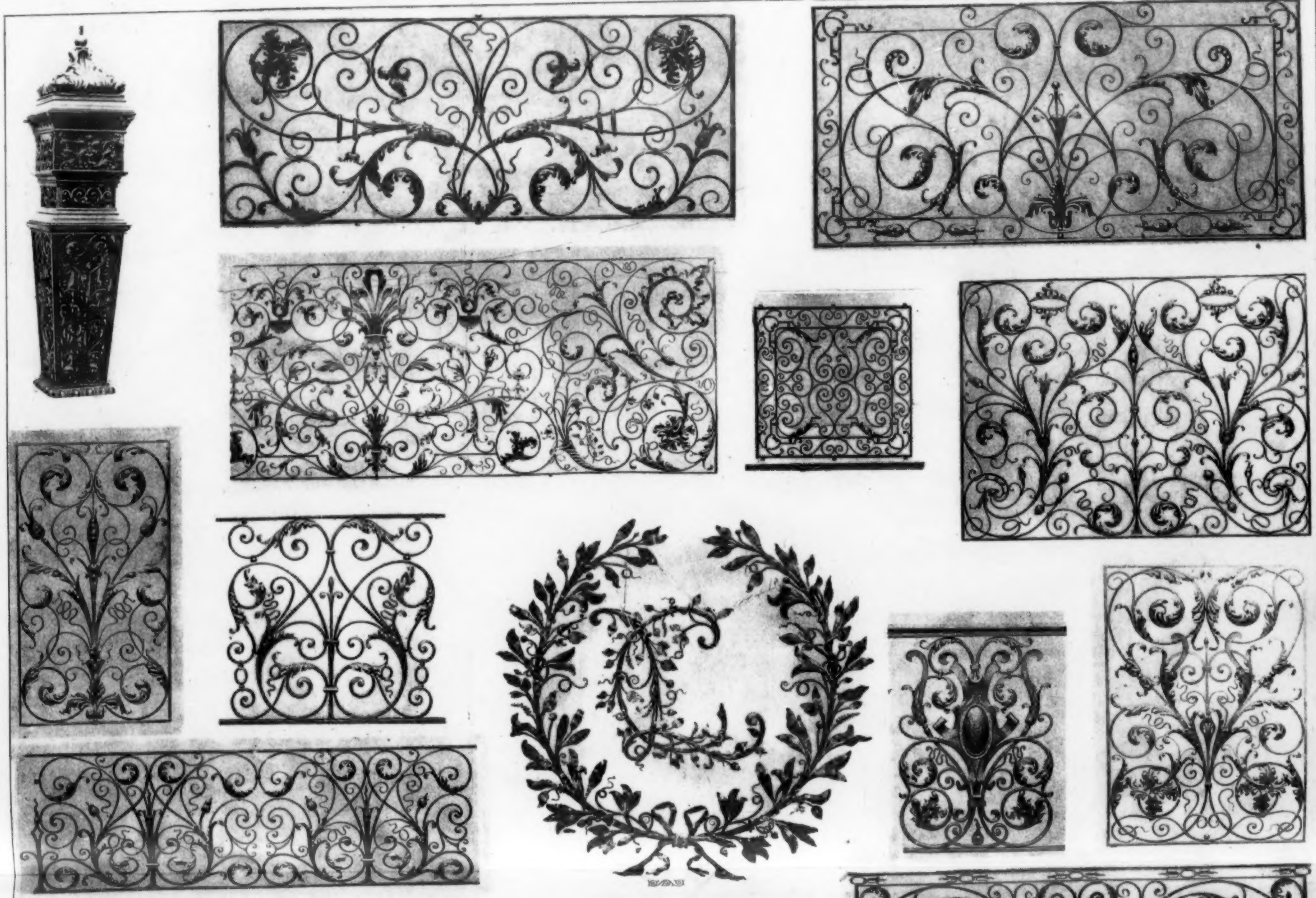


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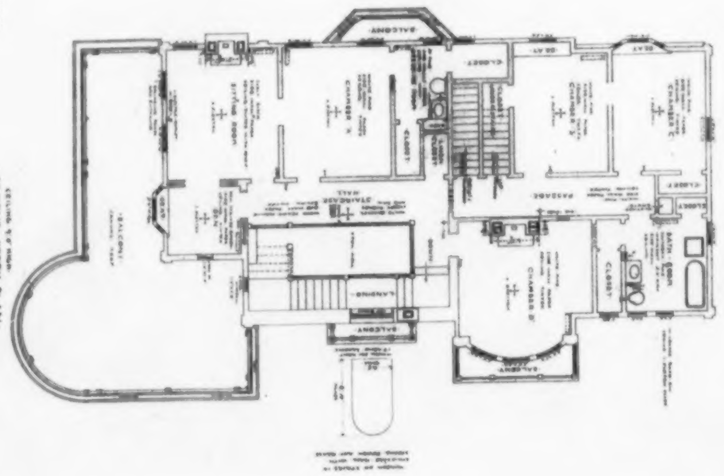

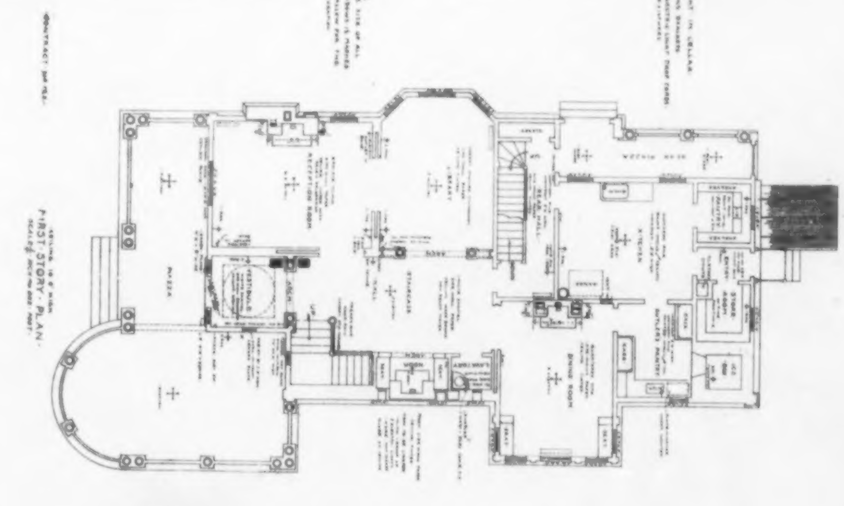

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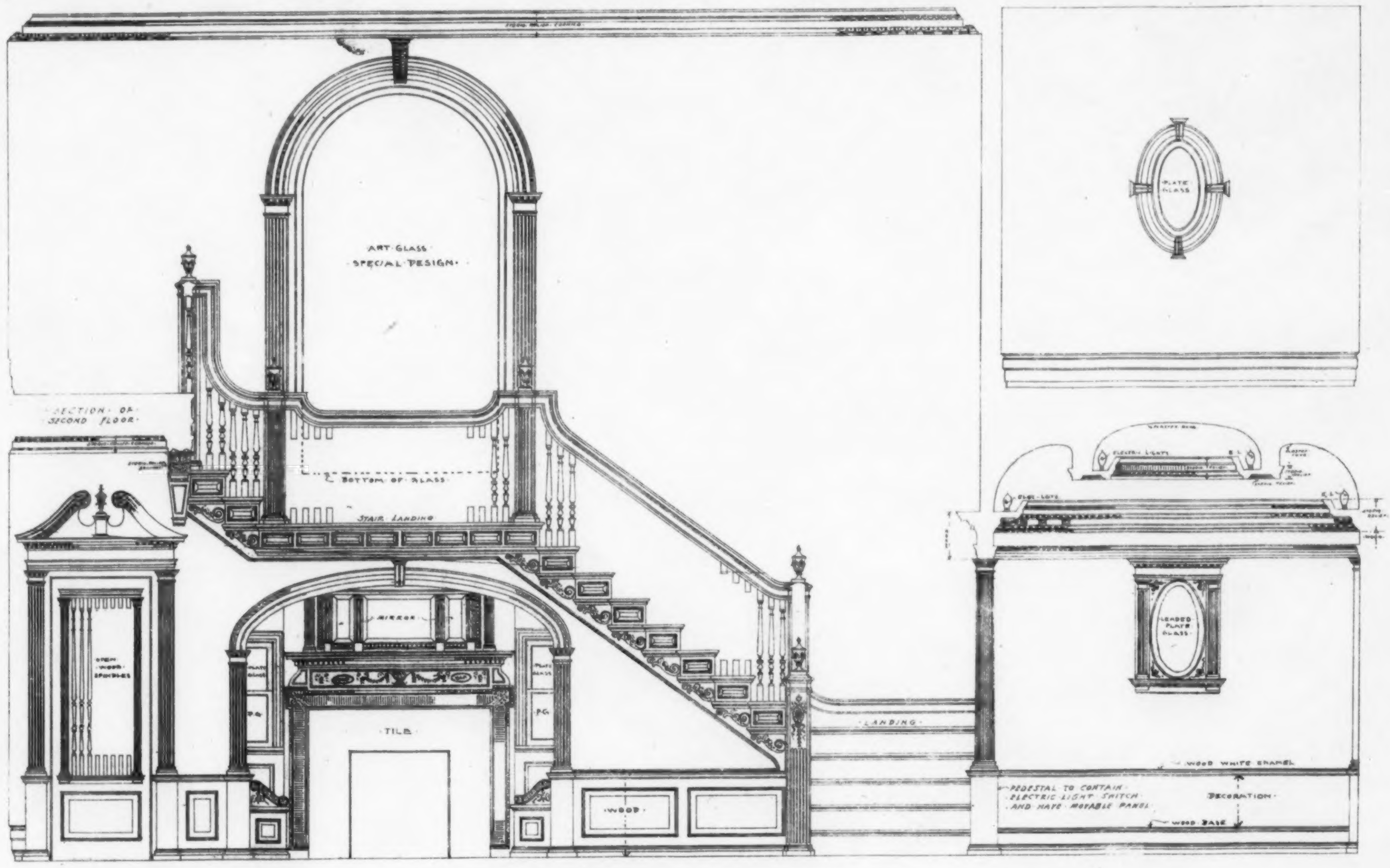
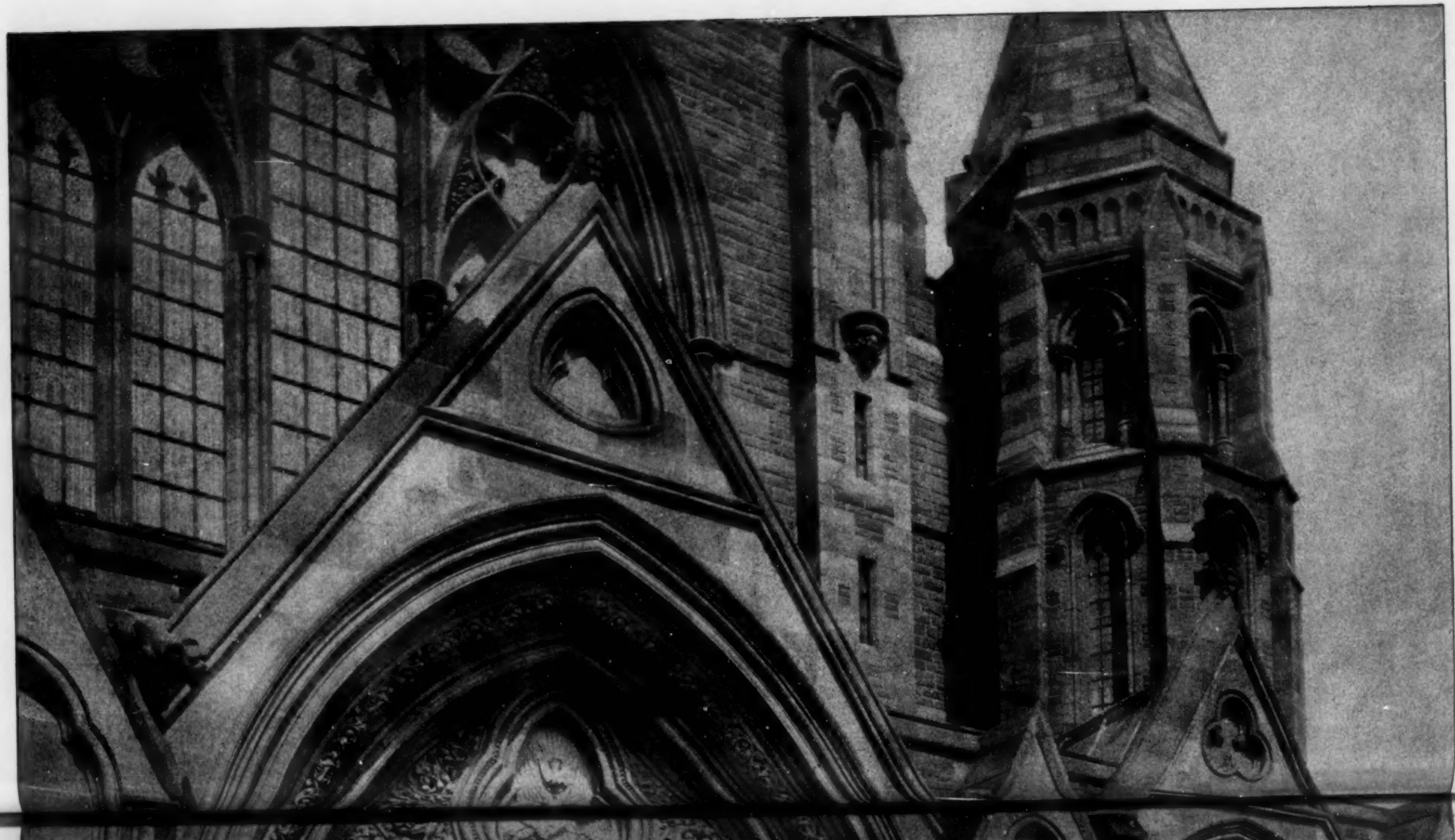
... Architect
Hartford Conn.



· ELEVATION · OF · STAIRS ·



PHOTOGRAPHED BY BEDFORD LEMERE & Co

INK-PHOTO. SPRAGUE & Co 4 & 5, EAST HARDING STREET, FETTER LANE, E.C.

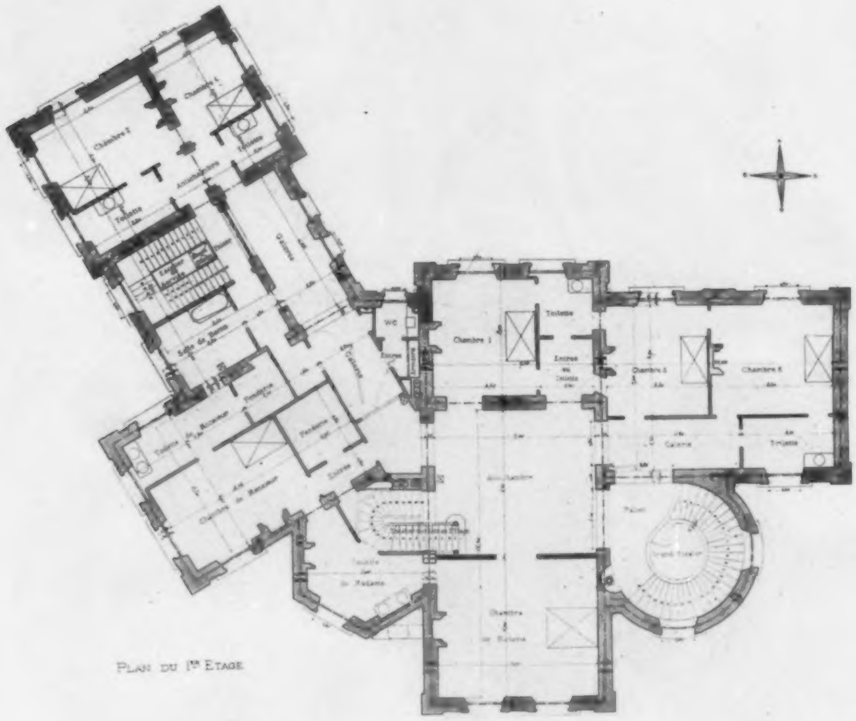
SOUTH FRONT: COATS' MEMORIAL CHURCH, PAISLEY, N.B.

HIPPOLYTE J. BLANC, Architect.

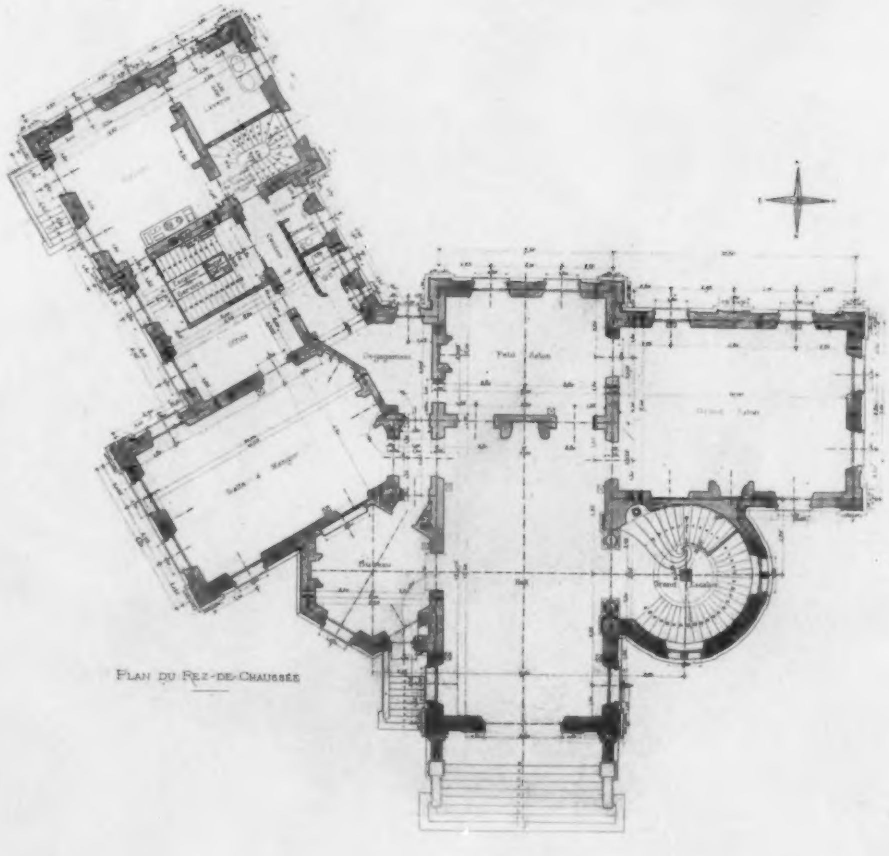
HOUSE OF BYRON NUGENT, ESQ., ST. LOUIS, MO.

WILLIAM ALBERT SWASEY, Architect.

THE HELIOTYPE PRINTING CO., BOSTON



Plan du 1er Etage



Plan du Rez-de-Chaussée

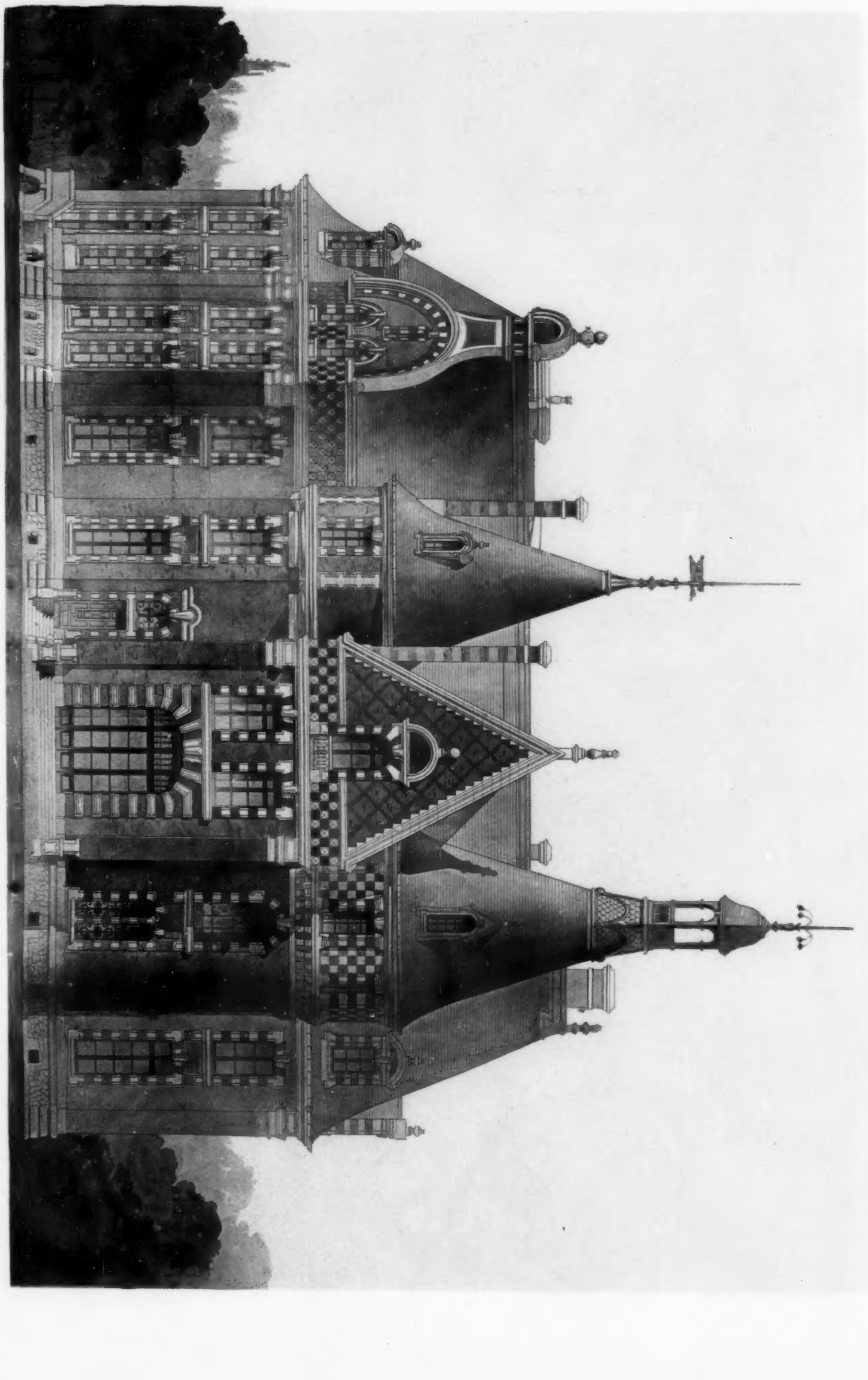
CHATEAU DE LA MOTTE-BELAIR (LOIRET)

Plans

Mr Louis Parent, architecte

Façade nord

Mr Louis Parent, architecte.



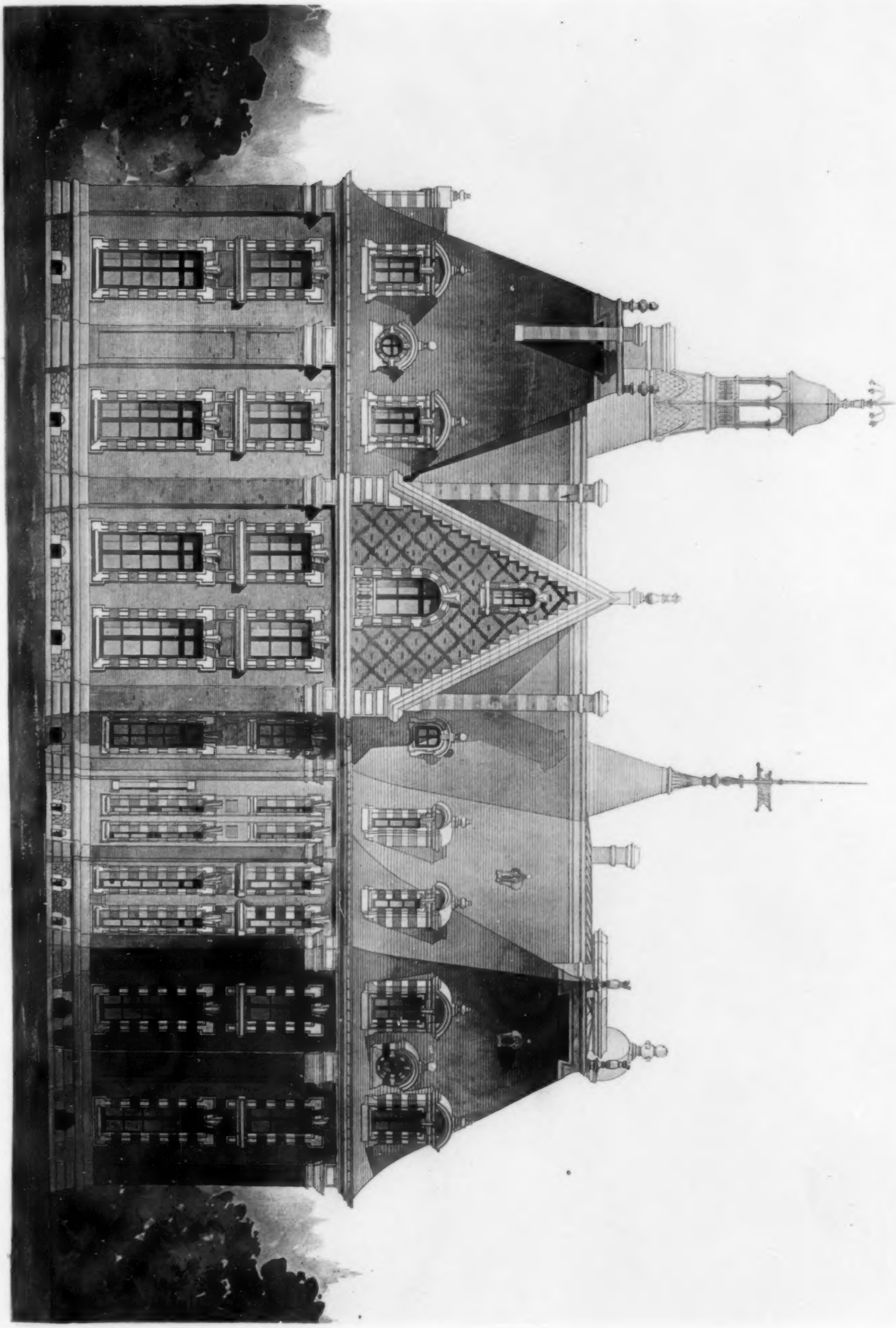
CHÂTEAU DE LA MOTTE-BELAIR (LOIRET)

Façade nord

Mr Louis Parent, architecte.

CHÂTEAU DE LA MOTTE-BELAIR (LOIRET)

Façade méridionale



CHÂTEAU DE LA MOTTE BELAIR (LOIRET)

Façade méridionale