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THE *Engineering News* and the *Engineering Record* have both made studies of the ruins of the recent great fire in Pittsburgh, from which some important facts have been ascertained. It seems that the earlier newspaper stories, to the effect that the so-called fireproof buildings affected were completely destroyed, were quite erroneous. Their contents were consumed, for the very sufficient reason that, as the buildings were almost entirely open, everything inflammable in them was exposed to the fire; but the structures themselves resisted the conflagration with very tolerable success, and the greater part of the steel-work is so far uninjured that it can be used without change in rebuilding. In general, therefore, this fire, instead of illustrating the inefficiency of our modern method of incombustible building, furnishes a striking evidence of the degree of success with which American architects have studied the greatest of modern structural problems, proving, not only that they have discovered the true principles of fireproof construction, but that they have advanced very far in the application of them. Some years ago, fire broke out in a great warehouse in Hamburg, Germany. Not only were the floors of the building all of iron and concrete, and the columns of iron, but it was subdivided by many brick walls, with only small openings in them; yet the building, after the fire, was, practically, a total wreck, some photographic pictures of it in our possession showing the columns crippled and bent, and the girders fallen, twisted in all directions. In contrast with these, the photographs of the Pittsburgh buildings, reproduced in the *Engineering News* and *Engineering Record*, show the steel columns, girders and floor-beams, with their connections substantially intact, except where a large iron water-tank, which was placed on the roof of one of the buildings, and is said to have been supported on a wooden framework, had fallen, through the destruction of its wooden supports, and, in consequence of the impetus due to its fall, had broken through the floors to the cellar. The terra-cotta covering of the columns was in some places, where the heat was greatest, broken away from the upper part of the column. The tile coverings of the girders had resisted even better than that over the columns; but the floor-arches were in great part destroyed, although the beams supporting them were not seriously injured. The floor-arches were of the ordinary "side construction," eight inches thick, and rested on skewbacks which covered the whole depth of the twelve-inch floor-beams, with a lip to cover the lower flange of the beams in addition. By a variation from the ordinary practice, the eight-inch arch blocks, instead of being set level with the bottom of the skewbacks, leaving a space over them, to be filled with concrete or cinders, were set level, or nearly so, with the top of the skewbacks, leaving four inches or so of the latter projecting beneath them. In very many cases, this portion of the skewback had broken off, the fracture being nearly in a plane running parallel with the direction of the beam, and cutting the nearest edge of the lower flange of the beam, and the point of intersection of the underside of the floor-arch with the skewback. Mr. O. H. P. La Farge, who examined the ruins for the New York Underwriters' Association, is of opinion that if the floor-arches had been set at the bottom of the skewback, in the usual way, very few of them would have failed. It may be noted that the protection used for the columns was of two-inch hollow tile, with a two-inch air-space, while the main girders had their sides protected in the same way, the soffits being covered only with single tiles. The efficiency secured by this construction shows its great superiority to the system of single tile covering, or of covering with two courses of single tiles, which has failed in previous fires; but the fact that at Pittsburgh the hollow tiles were thrown off from the upper part of some of the columns suggests that a further improvement might be made by setting them nearer the column. The photographs suggest curiously the idea that the tiles were thrown out by a sort of explosion, and the sudden expansion, by a sweep of the flames, of a body of air two inches thick, confined between the column and the close-jointed and plastered tiling, might easily produce such an effect. As a non-conducting stratum, half an inch of air would be nearly as good as two inches, and there would be much less danger of rupture from internal expansion.

AN important amendment to the building-laws has just passed the Massachusetts Legislature, by which it is required that all hotels, school-houses and tenement-houses hereafter erected within the fire-limits of Boston shall be "first-class buildings," that is, of incombustible materials throughout. While, apparently, a rather radical measure, this provision will, we are convinced, be in the end of great advantage to the city. That school-children, hotel-guests and the occupants of tenement-houses need better protection against fire than is now accorded them is obvious enough, but there is another point to be considered in the greater durability, and consequent economy, of incombustible construction, especially for large buildings. Every architect knows the hopeless state of sordid decay into which a building with wooden framing falls after a few years of neglect, and sills must be looked after and replaced, floors furred up, cracks in plastering, due to shrinkage of timbers, patched, doors thrown out of level by settlements "eased," and various similar operations carried on almost continuously to preserve a wooden building in habitable condition after it has passed its twentieth birthday; while, as travellers know, buildings, wholly or mainly of fireproof materials, such as most of those on the Continent, are, as a rule, habitable and handsome after an existence of three or four hundred years, and many an unpretending house in Southern France or Italy has been occupied continuously for six or seven hundred years, and is still very serviceable. Viewed as an investment, therefore, a well-planned school-building or hotel of fireproof materials is far more desirable than one of perishable materials. Supposing that the fireproof structure costs ten per cent more than the other, the annual interest on the extra investment is not more than one-half of one per cent on the total cost of the building, and the structure is practically as good, and as rentable, or as useful for school purposes, in its twentieth year as on the day of its completion. With the combustible building, on the other hand, repairs and deterioration begin at the outset. Insurance-men are said to reckon these at five per cent annually on the cost of the building, which is probably too much, but, supposing it to be half of that, the whole amount of the original investment will have been sunk in forty years. The fireproof building, erected at a cost greater by ten per cent, will then show an advantage in cash outlay of eighty per cent on the total investment, and its rental value will be nearly as great as ever, while the combustible building, after having been paid for twice over, will be a mouldy, rotten, crazy shell, at best, of little or no value as an investment.

IT is sometimes objected to the theory that fireproof building is economically advantageous that, unless houses burned down or rotted away rapidly, they would accumulate, so that the market would be overstocked, and rents would fall; and the French and Italian cities, where the income from improved real-estate is only about three per cent, are mentioned as presenting a sad example of what might come to pass in this country; but many an American real-estate owner would be glad to exchange his houses, which show, at the end of the year, a gross income of eight per cent, with an outlay for taxes and repairs of nearly the same amount, for French or Italian property representing the same investment; and, if his tenants pay less rent than he would like, it must be remembered that his own rent, and the cost of the things which he buys, into which the expense of rent enters as a factor, is diminished in similar proportion. Practically, however, the multiplication of fireproof buildings in our cities is not likely to lead to the reduction of rents for a long time yet. On the contrary, it will bring about a great and rapid diminution of fire-losses, which now, it must be remembered, impose a tax of about twenty dollars a year on every family in the United States, and thus materially increase the ability of tenants to pay satisfactory rents; while the saving in cost of repairs will make a real, and very considerable, addition to the net income from the property, even with rents nominally reduced.

THE Department of Communications and Public Works of Mexico has issued a call for designs for a new Capitol Building, to be known as the Palace of the Federal Legislative Power. Architects of any nationality may compete, and the descriptions and lettering on the drawings may be in Spanish, French or English. The total cost, exclusive of foundations below ground, must not exceed a million and a half of dollars. Designs, with estimates, must be sent to the Minister of Communications and Public Works, in the City of Mexico, before November 1 next. There is to be a Jury of Award, composed of seven members, who may be either civil engineers or architects. One of the members is to be appointed by the Chamber of Deputies, one by the Senate, and one by the Department of Communications and Public Works; and the other four are to be elected by the competitors from among ten candidates, nominated by this department, each competitor to enclose a ballot for four jurymen with his design. The author of the selected design will receive a premium of fifteen thousand dollars, and six thousand dollars will be divided between the authors of the designs placed second and third, as the Minister may determine; while the authors of the fourth and fifth designs will receive five hundred dollars each, with medals and diplomas. All these sums are, of course, reckoned in Mexican currency.

IT is no longer lawful in New York to drive a rattling cart about the streets, or in other ways to make a noise to the disturbance of citizens. On March 11 an ordinance went into operation, by which it is made compulsory upon those charged with the transportation of iron bars, or other objects likely to cause noise by rattling, to place cushions under them, or take other measures to prevent such noise; and, a few days ago, a teamster in whose wagon were some iron rails not thus treated was arrested, and fined twenty-five dollars. Without desiring to emulate the inhabitants of Sybaris, who would not suffer even a blacksmith's shop within the city limits, lest the noise of hammering might disturb their nerves, the people of this country might well adopt generally the practice begun in New York, and treat unnecessary noise as a trespass on the rights of the innocent persons annoyed by it. There is no doubt that the lives of the people who inhabit our great cities are not only made uncomfortable, but materially shortened, by the continual racket in the streets, much of which is not merely careless and unnecessary, but malicious, for nothing seems to please the bucolic teamster more, on his arrival in the city, than an opportunity for deafening the ears of the passers-by by such noises as his lungs, or the loose objects in his cart, are capable of producing. In and about our railroad-stations the case is even worse. Railway-trains in Europe are so managed as to move almost noiselessly. In the stations, particularly, they glide quietly about, a momentary sound from the whistle only giving the signal of departure; while every movement of a train, with us, is accompanied, in the stations or yards, with a continuous clanging of an enormous bell, even this being overpowered, in the case of incoming trains, by a deafening roar of steam escaping from the safety-valve, or, with outgoing trains, by the tremendous blasts of the forced draught, which shake the station-buildings by their violence. It is possible that it is necessary for railroad companies to hire men to ring huge bells for the sole object of tormenting their passengers and the public, but it is certainly not necessary for them to blow their stockholders' money into the air through the safety-valve and the forced draught. In regard to every other sort of machine, Americans have long ago realized that all energy consumed in noise is so much dead loss, added to an unnecessary wear and tear of the apparatus, and American machinery, as a rule, runs more quietly than that built abroad; but American locomotives, for some reason, are almost always operated with a clatter and roar which would not be endured abroad for a day.

THE school carried on in Rome by the American Archæological Institute seems to have had a very successful year. The Villa Story, long the home of the sculptor Story, has been secured for the school, and possession was taken last autumn. Nine regular students, and two women, as special students, were in attendance through the school year, and lectures were given, not only by the Director, Professor Minton Warren, of Johns Hopkins University, and Professor Allan Marquand, of Princeton, but by other distinguished scholars, now resident in Rome — Huelsen, Stevenson, Marrucchi, Loewy and Mau.

CORNELL UNIVERSITY has established in its Architectural Department a new chair, that of Architectural Design, and has offered it to Mr. Van Pelt, who has accepted it, and will begin his duties next autumn. It will be remembered that Mr. Van Pelt is one of the most distinguished of the American students of architecture at the Paris School of Fine-Arts, and has carried off many recompenses of various sorts, the last being a first-second medal, awarded to him last month in the regular competition of the first class; and it may well be hoped that his accession to the ranks of the teachers of architecture in this country will be a notable event in the history of American art.

THE *Northwestern Lumberman* has had its attention called to the fact which most architects have noticed, that shingle roofs become "nail-sick," or fail, through the rusting-off of the nails in them, much sooner now than they did before the days of wire shingle-nails and Bessemer steel nail-plates. It is only a few days since we saw a shingle roof which had been in great part stripped by the wind, although the shingles, which were lying in heaps on the ground, were apparently good for twenty years more of service. The trouble was evidently with the nails, and so common has such trouble become that galvanized or cement-coated shingle-nails are, in this part of the country, rapidly taking the place, in architects' specifications, of the unprotected sort.

THE consolidation of all the principal libraries in New York into one great New York Public Library is in many ways an important matter. There have always been books enough in New York, but it has been difficult to obtain access to them. In some cases, library hours have ended at sunset, so that evening work was impossible; and, while the Astor Library was rich in books of one sort, others were more plentiful at the Lenox Library, so that a student might have to travel several times over the three-mile interval between them before he could collect the information that he needed. After consolidation, the books of these two libraries, together with that belonging to the Tilden Foundation, will be gathered in one building, catalogued together, and made available under a uniform system, greatly to the advantage and convenience of the people who use them. The new Library Building is to be on Bryant Park, or, as it was formerly called, Reservoir Square, between Fifth and Sixth Avenues, and Fortieth and Forty-second Streets, a very central and convenient location. A competition, limited to architects with offices in New York, has been called, and the professional world will watch the contest with interest which will be increased by the fact that the Trustees do not offer such terms of competition as have been agreed upon among many of the principal architects of the city, and the struggle will, therefore, be mainly among the less-known men

WIND-PRESSURES ON HIGH BUILDINGS.[1]

The Cross, Thornhill, Dumfriesshire, Scotland.

WE have been particularly requested to lay before our readers an abstract of the long, but very valuable, paper on wind-pressure prepared by Mr. Julius Baier, Assoc. Mem. A. S. C. E., but it has seemed best to us to print the following copious extracts from his paper rather than a briefer abstract: —

THE storm of May 27, 1896, entered St. Louis from the west, progressed eastwardly through the city at some distance south of the central business section, crossed the Mississippi River and continued in a northeasterly direction through East St. Louis. . . .

The anemometer record shows the passage of 13 miles of wind in about 12 minutes; of this, a little over 6½ miles passed in 5 minutes, a rate of about 80 miles an hour observed, giving, when properly corrected, an actual velocity of about 62 miles per hour. The general direction was towards the south, into the storm centre. . . .

A general inspection of the buildings brings out the following average characteristic features. The extreme force of the wind was generally confined to upper stories and roofs. The intensity of this force must have been extremely variable, not only as exerted on adjacent properties, but on a single building. There was very general evidence of the destructive force being exerted from the inside.

The total number of buildings destroyed or seriously damaged by the storm in the City of St. Louis, as shown by the records in the Assessors' office, is 7,263. Of these, 321 were totally wrecked. The number of houses slightly damaged that can be repaired at an average cost of $75 is 1,249, making a total of 8,515. . . .

The general maximum destruction covers an area from 4,000 feet to 6,000 feet wide and nearly 3 miles long, lying immediately south of the central part of the city in St. Louis and extending across the river into East St. Louis. . . .

Throughout the path of the storm the buildings and wreckage show evidence of extreme and sudden variations in the intensity of the wind-pressure. A striking example of this is a little pavilion left standing in Lafayette Park, on a slight elevation above the general level, at a point where the broken and uprooted trees show the full force of the storm. A straw-thatched roof held in a light wire netting and perched on six uprights planted in the earth and stiffened by a few rustic braces, it would seem a most inviting mark for the wind, but except for some damage due to the falling limbs of adjacent trees, it stands uninjured. . . .

Any formula expressing the relation between the pressure and velocity of the wind must be based on the assumption that the air flows in a uniform current. All experiments in the open air show that the actual conditions are far different, and the great diversity in the observed results is due largely to the continued and rapid fluctuations in the velocity of the winds. . . .

As a result of these observations Professor Langley reaches the conclusion that "the wind is not even an approximately uniform moving mass of air, but consists of a succession of very brief pulsations of varying amplitude, and that relatively to the mean movement of the wind, these are of varying directions."

Regarding the direct effect of wind-pressure on buildings, some suggestive results were obtained by Professor Kernot[2] with an apparatus devised to determine the relative pressures of the wind on flat plates, cubes, cylinders and other forms similar to those employed in ordinary construction. A steady jet of air 10 by 12 inches in cross-section was directed against small models supported on a very delicately arranged carriage running on an accurately levelled surface-plate, the force exerted being measured by a delicate spring balance. From a large number of experiments made with this apparatus he found that the pressure on sloping roofs agreed with the results of theory only when the air could blow freely underneath. With the model of a roof placed on a wall, as in an ordinary building, the air was deflected upward and greatly reduced the pressure on the roof; the effect was more marked when a parapet was used. In the case of a roof of 30° pitch, with a parapet 0.16 the height of the roof, the pressure was actually reversed, the roof having a slight tendency to lift. Experiments were tried as to the effect of the wind blowing in at the open end of a building having the sides and other end completely closed, and it was found that there was an internal pressure, tending to lift the roof and force out the sides, which was equal to the pressure of the wind on the exposed end. When a plain surface, parallel to the wind, was brought nearly into contact with the cylinder, the pressure on the latter was increased nearly 20 per cent, owing to the lateral escape of the air around the cylinder being checked, showing that a tower or chimney will be subjected to a much greater pressure if there is a building nearly touching it on one side. The variations of pressure caused by the proximity of other surfaces were very marked; each surface appeared to affect the pressure on the other surfaces to a distance in front equal to its own breadth, and in the rear equal to several times this distance. Behind flat surfaces eddies were found to exist which caused other surfaces placed behind them to be urged forward with considerable force.

The existence of a suction on the leeward side of surfaces or bodies exposed to the wind has been generally recognized, but the experiments of Mr. Irminger,[3] a Danish engineer, made to determine the amount of such suctions, shows it to be present to an unexpected extent. . . .

The most interesting result was that found for a roof sloping at an angle of 45°. The pressure on the windward side was a maximum at the eaves, and became zero near the top, changing to a suction at the ridge. The effect on the leeward side was a uniform suction. Taking the normal pressure on a plane of the same dimensions as equal to p, the proportional effect on the windward side was found to be a pressure of $0.11\ p$, and on the leeward side a suction of $0.36\ p$. The resultant effect on the total roof was a force 3½ times as large as the pressure on the windward side alone, and was inclined upward, exerting a strong lifting action. In another experiment made with the model of a building covered by a dome, the resultant of the pressure and suction upon the dome was found to act vertically upward.

The results of these experiments show that the wind acts in a direction quite different from that generally assumed and usually provided for in the designing of bridges, roofs and buildings. The evidences at St. Louis confirm this conclusion. . . .

Much of the destruction in St. Louis was undoubtedly caused by an intensity of wind-pressure that it would be neither possible nor expedient to provide against in ordinary structures, but much of it was also due to weak construction. A general observance of the ordinary requirements for good building work would largely decrease the damage due to such storms. The great amount of explosive action was largely due to the comparative weakness of ordinary walls against pressure exerted from the inside of buildings. A more efficient anchorage of the walls might limit this explosive action to the windows. In numerous instances the windows were blown in on the windward side, while the entire wall was blown out on the leeward side. Brick walls are materially stronger if well bonded with the vertical joints filled with mortar, and a wall laid in cement will undoubtedly withstand a greater lateral force than one laid in lime-mortar. It is worth noting that the walls of the buildings of the Union Depot Railway plant left standing were laid in cement, while the older buildings, which were entirely wrecked, had walls laid with lime-mortar. The great damage done to the churches calls attention to the great exposure of the steep and lofty roofs supported on high and comparatively thin and unbraced walls. Heavier buttresses or independent steel column supports, with bracing for the roof trusses, would materially increase the safety of such structures. In general, the buildings with large areas of unbraced walls have suffered most. . . .

The periodic prevalence of these storms emphasized by the recent calamity in St. Louis, by the destruction in Louisville in 1890, and by a similar storm in Little Rock in 1894, and in Kansas City in 1886, gives a somewhat broader public interest to this question, and appears to call for its serious consideration. The evidence of the work of the wind in St. Louis suggests as an immediate answer to the question that it will depend largely upon the nature of the metal framework in the building. . . .

The metal framework of a building is somewhat generally called the "skeleton" and sometimes a "cage." If both of these terms are to be retained in this special sense, a convenient distinction can be made by some restriction in their use suggested by the words themselves.

Skeleton is a term clearly descriptive of that type of construction to which it was first applied, a simple framework of columns and beams whose efficiency is dependent largely on the existence of exterior walls and partitions which brace the building, and hold the framework in position, just as the utility of the human skeleton is dependent on the covering of sinews and muscles that hold the component parts together. On the other hand, the light framework of an ordinary wire cage bound into one compact unit is suggestive of an inherent strength and elastic resistance that renders any covering an incident rather than a necessity. Cage is a term peculiarly descriptive of that type of construction represented by the most advanced and approved practice, a framework of columns and beams, spliced at the joints, riveted at the connections, stiffened by an efficient bracing of rods, portals and gussets that make it independently safe against any external force, leaving the thin and light exterior walls with no duty except that of providing protection and ornamentation for the building.

The effect of an extreme wind-pressure on a high office-building with curtain-walls must depend largely on the extent to which the

[1] Extracts from a paper by Julius Baier, Assoc. M. Am. Soc. C. E., read before the American Society of Civil Engineers, and published in the *Journal* of that Society.

[2] *Engineering Record*, February 10, 1894.

[3] *American Architect*, September 14, 1895.

frame of that building partakes of the nature of the skeleton type or the cage type of construction.

The possible work of destruction of a tornado may appear more clearly if, as Ferrel suggests, the column of rapidly revolving air is likened to a tall flue, with heated and rarefied air in its interior. If the access of air is cut off from the lower central part by the shell of gyrating air extending down to the surface, the lateral currents and ascending currents in the interior will be of no violence, but with a somewhat free access of air below into the rarefied interior, on account of a decrease by friction of the gyratory velocity near the surface, the inrush of lateral air-currents becomes extremely violent and the velocity of the uprush of air in the interior becomes enormous. In the former case the destruction is mainly due to the excessively high gyratory velocities; the destruction is complete, but the path narrow. It is the condition that may prevail in open country with but few objects to destroy the energy of the tornado. In the latter case the destruction is largely due to the violent lateral inrushing currents. The path is wider, and the force not so extreme. It is the condition which must prevail in any compactly built city, owing to the great friction of the air arising from the irregularities due to the many buildings.

The first high isolated building encountered will feel the full force of the gyratory velocity, but the resistance of the building destroys this velocity and the work of destruction wrought on that building must represent an equivalent diminution of energy in the lower section of the tornado, which can only be renewed by its further unobstructed progress during such appreciable time as is necessary to restore the gyratory velocity. A succession of high buildings will prevent such recovery of velocity.

The destructive power of a tornado on massive building work due to these excessively high velocities is therefore soon exhausted, but the wind-pressures due to the violent currents rushing in from all sides are only intensified thereby.

If a tornadic storm with a well-developed whirl should pass through the section of any city containing very high buildings, the general level of the top of the lower buildings becomes equivalent to the ground surface, and it seems fair to assume as the result the same general action that has been found near the surface, modified or intensified in its irregularity according to the degree of uniformity in the general height of the majority of the buildings. There may be the extreme pressures due to the gyratory velocity of the tornado proper exerted over a limited area and for a very limited time. There will be a far wider zone of lateral inrushing winds at high velocities lasting throughout the progress of the tornado and attended by the additional complications that may arise, due to the concentration of air-currents in the deep valleys formed by the streets between the buildings. The probable result would be an extremely variable and intense action of the wind about the tops of the lower buildings, the same action concentrated locally at about that level on the higher buildings, accompanied with a general severe pressure over the entire exposed area of the latter, this latter pressure probably being a maximum near the top or at least some distance above the general level where the friction is not so great.

A characteristic feature of the St. Louis tornado, and one which, judging from records and published views, is also common to other tornadoes and violent hurricanes, is the general destruction of the ordinary brick and stone walls. Regardless of the sequence in which they may explode outward or are blown inward, and of a possible difference of opinion as to whether the explosion is due to a plenum, a vacuum or to a suction, the essential fact remains that the walls do very generally fall.

Assuming a similar action of the wind, the buildings of an average height will probably have the walls at the top or exposed corners destroyed, or, if particularly weak, may be shaken down. The buildings above the average height would be very liable to have part of the walls at any level blown in or taken out. An office-building with the curtain-walls of one or more stories removed would support the remaining enveloped superstructure precisely in the manner of the grain-elevator before it was struck by the storm.

If, now, the building is of the pure skeleton type, it will have only the elements of stability that existed in the case of the elevator — its weight — above the floor in question, and possibly some additional bracing of a more or less uncertain value, and under the action of even such pressure as may exist at some distance from the vortex of the tornado, it will fail, just as the elevator failed; it will topple over and fall to one side or towards one corner on the floor below. Instead, however, of landing on a massive stone foundation, the thousands of tons of weight of the three, four or six stories, as the case may be, of the upper section of the building will fall with a crushing force, concentrated on the leeward side, on the section below. The heavy oak girders under the leeward edge of the elevator were mashed into a bundle of splinters, while the windward edge was held some distance above the foundation. As the striking force of a freely falling body is equal to the product of its weight multiplied by the distance through which it falls — about 12 feet in the case of an office-building falling one story — the resulting pressure on some of the columns may easily be ten to twenty times the load they were designed to carry and several times their ultimate strength; the result must be a collapse of part or all of the lower section, with a possible toppling over of the upper section to one side into the street or onto a lower adjacent building.

If the building is of the cage type, it will stand safely under a wind-pressure that will destroy the skeleton building. While the failure of the walls at any story may reduce the rigidity somewhat, it cannot affect the strength of a framework designed without placing any dependence on the covering. Such a framework will readily carry the lateral stresses from the upper section to the section below.

If the pressure should reach a destructive intensity, the exact line of yielding of a cage frame is not so clearly defined. The tendency to lateral displacement will be a maximum at some one story, depending on the distribution and cumulative effect of the wind-pressure, aided possibly by the weakening due to localized failure of walls or partitions. As the frame is of a gradually varying strength from the top down, the distortion can hardly be confined to one level, but would probably involve the members of the adjacent stories, the effect being a general racking or leaning of the building. With strains near the ultimate strength, the failure at some point may concentrate a distortion at that level, and the upper section of the building may be pushed to one side and ultimately settle down on the floor below.

The essential difference lies in the fact that a wind of sufficient force and duration to push the upper section of a building to one side a distance about equal to the width of a column, may cause total destruction in a skeleton building, while a cage under the same circumstances may suffer only a local damage that can possibly be repaired at a comparatively small cost. In a skeleton building, the instant the columns are pushed beyond the critical or balancing point, the weight is reversed in its action from an element of safety to an almost unresisted element of destruction. With a cage type of construction the weight of the building after some displacement has taken place also acts with the wind as a destructive agent, but not unresisted. The work that must be done in the necessary bending, twisting and general distortion and breaking of the metal in the columns and beams must largely absorb the energy of the falling mass and have the effect of letting it settle down on springs. The local peculiarities of the building, the unequal distribution of the wind-pressure, and the changing direction of the wind, make it more than probable that such failure will not be symmetrical, but will have a torsional effect on the upper section of the building.

However difficult it is to foresee the many possibilities, it is safe to assume that in one way or another the framework will hang together sufficiently to prevent any considerable part of the building from falling down bodily onto streets or buildings below. Even under the most extreme conditions it is difficult to conceive how such a building, or a large part of it, can entirely collapse. The general destruction of windows and walls will greatly relieve the wind-pressure; the frame, partly bent, twisted and distorted, must still hold together. The chances are that most of the occupants will escape alive and many uninjured. The most striking feature of the St. Louis tornado is the countless number of hairbreadth escapes and the very small number of people killed inside of houses unless by the entire collapse of the structures; incredible as it may seem, under such extreme conditions, the fatalities attending only local failure of a building are comparatively few.

The effect of a destructive wind-pressure on any high building with curtain walls may be assumed to approach that outlined above in proportion as its framework partakes of the nature of a skeleton or cage type of construction, using these terms in the restricted sense indicated in this paper.

The destructive effect of the total collapse of buildings has been too frequently noted to require further mention. The method of failure of the grain-elevator, taken in connection with the view of the wreck of the skeleton framework, indicates what might happen to a high building of the pure skeleton type if brought to the point of failure. The assumed action of the cage type of building is dependent on an efficiency in general design, and particularly in the detailing of connections which can be readily attained if the necessity for it is recognized. In the absence of any definite tests of full-sized typical details used in the structural work of buildings, the action of the metal under extreme distortion must be estimated from the results shown by sample specimens, verified by occasional opportunities to notice its behavior under accidental tests of great severity that may be caused by collisions or derailments on or near bridges and viaducts. The riveted joints, mentioned earlier in the paper, show what may be expected in details involving similar principles of design.

The possibility of a high office-building being actually subjected to a destructive wind-pressure has often been considered, largely in the light of a theory. The St. Louis tornado passed within less than a mile of the office-buildings in that city. Fortunately it made no test of the buildings, but it has left some definite evidence of the possible force of the wind and of the action of this force on the materials of construction. While it raises anew the question as to the amount of wind-force which should be provided for in designing high buildings, it raises with more emphasis the question as to the method of providing for this force after its amount has been assumed. Any dependence placed on curtain-walls and partitions for lateral strength is open to very grave question. The rigidity imparted to a building by the simultaneous action of the total mass of material under ordinary conditions is no indication of the ultimate strength that may be developed at a critical moment, and the very general failure of the walls under extreme wind-pressure further destroys any certainty of such assistance as might be otherwise relied upon.

The elements of safety against wind-force, exclusive of the strength that may come from the walls and partitions where they exist, are the stability due to weight alone, stability due to the strength and stiffness of the frame, and, when the force is a sudden one, the inertia of the mass resisting motion.

It may be of interest to estimate just how sudden and how short-lived the force must be to justify placing any dependence on the inertia of the structure for safety. The force required to set in motion and move over a given distance any mass, otherwise balanced, is capable of exact computation if the time allowed for such motion is known. The equation is derived from the law for falling bodies and is $F = \frac{2wd}{gt^2}$, where F is the total force, w the weight moved in pounds, d the distance moved over in feet, t the time in seconds, and g is 32.2.

The following table, computed from this formula, gives the force required to overcome the inertia of a ton of 2,000 pounds and move it varying distances in times varying from one second to thirty seconds.

FORCE PER TON REQUIRED TO OVERCOME THE INERTIA OF AND MOVE ANY GIVEN MASS.

Time in Seconds.	Distance Moved.									
	1 in.	3 ins.	6 ins.	1 ft.	2 ft.	4 ft.	6 ft.	8 ft.	10 ft.	16.1 ft.
1..	10.3	31	62	124.22	248	497	745	994	1,242	2.000
2..	2.6	7.7	15.5	31	62	124	186	248	310	500
3..	1.15	3.4	6.9	13.8	27	55	83	110	138	222
4 .	0.64	1.94	3 9	7.7	15 5	31	46	62	77	125
5..	0.41	1.24	2.4	4.9	9.9	19.8	30	40	49	80
6..	0.28	0.86	1.72	3.4	6.9	13.8	20.7	28	34.5	55
8 .	0.16	0.48	0.97	1.94	3.8	7.7	11.6	15.5	19.4	31
10..	0.10	0.31	0.62	1.24	2.4	4.9	7.4	9.9	12.4	20
15..	0.046	0.14	0.27	0.55	1.10	2.21	3.3	4.4	5.5	8.9
20..	0.026	0.078	0.155	0.31	0.62	1.24	1.86	2.5	3.11	5.0
30 .	0.012	0.035	0.069	0.138	0.28	0.55	0.83	1.10	1.38	2.22

Assuming, as an illustration, the weight of a ton suspended as a pendulum by a very long cord; then to swing it 1 foot in one second will require a force of 124.2 pounds, while the mere pressure of 1¼ pounds will accomplish the same result if the time allowed is 10 seconds, or about the average duration of a gust of wind in Professor Langley's experiments. Applying the figures in the table to the case of a narrow building, say 32 feet wide, and assuming the upper section 100 feet high by 100 feet long, having thus an exposed area of 10,000 square feet to weigh 5,000 tons, then the force necessary simply to overcome the inertia and move this part of the building the respective distances of 1 inch or 1 foot or 16 feet, in various intervals of time, is equivalent to a pressure per square foot of the exposed areas as follows:

t.	$d = 1$ in.	$d = 1$ ft.	$d = 16$ ft.
1 second.	5.2 lbs.	62.1 lbs. per square foot.	1,000 lbs. per square foot.
2 "	1.3 "	15.4 " " " "	250 " " " "
3 "	0 5 "	6.9 " " " "	111 " " " "
5 "	0.2 "	2.5 " " " "	40 " " " "
10 "	0.05 "	0.6 " " " "	10 " " " "
15 "	0.02 "	0.3 " " " "	4.4 " " " "

These figures will readily indicate how great a resistance the inertia of a building may offer against the motion necessary to overturn it under the action of a brief gust of wind, and how comparatively little this resistance becomes as against only such motion as is necessary to push it over on its supports. To overturn the building in ten seconds, a pressure of 10 pounds per square foot is necessary to give it the necessary motion, in addition to the force required to overcome its stability. The resistance of inertia for a movement of 1 foot against a gust five seconds in duration will be 2.5 pounds per square foot, and for ten seconds it will be only 0.6 pounds per square foot. For shorter periods the value of inertia becomes very high, but may on the other hand be entirely overbalanced by the cumulative effect of the vibrations of the building acting in rhythm with the pulsations of the wind. Experiments on Chicago buildings under heavy winds show the time of a complete vibration to be about two seconds. The resistance of inertia against the destructive effect of brief but intense pressure, such as the gyratory velocities in the vortex of a tornado, is fortunately very great.

Stability due to weight alone is proportional to that weight and to the breadth of base of the support. Its value as an element of safety is a most definite one, and may be sufficient. Considered with reference to overturning, a large elevator or building may be safe beyond all question, yet with reference to its column supports the same structure may be in comparatively unstable equilibrium, as a relatively small movement of the centre-of-gravity will throw it out of balance. The total force required to overturn a building of a given weight increases directly with the breadth of that building, but the total force required to push it over on its supporting columns is a constant, depending solely upon the height and breadth of base of those columns, and is independent of the dimensions of the building, of the number of supporting columns, or the material they are made of. Any structural member that is used simply as a prop or support can have only such value as is incident to that use, whether it is made of wood, of stone, of cast-iron, or of steel.

The elements of strength and safety inherent in a well-designed cage built of the proper material, with all its members thoroughly riveted together, are present in that frame in greater or less degree, until it is torn or cut apart, piece by piece. A steel frame built to be safe for a wind-pressure of 30 pounds per square foot, proportioned by unit strains of one-half the elastic limit, would probably withstand a pressure from 40 to 80 pounds per square foot before the frame yields. This range depends largely on the care with which the connections have been detailed, the extent to which possible unequal settlement of the foundations has already overstrained the frame, and on the reduction of the effective surface exposed to the wind by the destruction of the walls in the panels between the framework, leaving part of the wind to blow through unresisted.

The details of construction that provide lateral strength and safety against an assumed wind-pressure are of the first importance. The subject of this paper, however, suggests a further consideration of these same details of construction, assuming that they may be strained by wind-pressures beyond their safe limits. If a building is never under any circumstances to fail, the problem is completely solved as soon as it is designed to stand under the assumed pressure. Assume that it may some day be brought to the point of yielding, and immediately some pertinent questions arise as to the possible results.

While the destruction and loss of the upper section of a building may be a matter of serious consideration to the owner, the disposition which a tornado would make of that section of the building may be an equally or more serious matter to the adjoining property-owners. If it is impossible to foresee the extreme force of the elements, or impracticable from economic reasons to provide against them entirely, it certainly is rational to make such modifications in a design as will reduce the possible disaster and damage to a minimum. A very material increase of safety in this direction can generally be secured at a comparatively small additional expense, depending largely on the attitude of the designer to the problem. The design of a building to be subjected safely to a given wind-pressure and never to any more is a definite problem involving only arbitrarily fixed working stresses. A design of that same building for the same condition of safety, but with the further recognition of the fact that it may be exposed to destructive pressures and with an effort to develop the ultimate strength and resistance of the material in the cage to resist those pressures, is a problem that will develop some additional considerations.

A destructive lateral force exerted against the upper section of the building will not be lost or dissipated, but must follow some well-defined path till it reaches the foundation. If a building is to fail laterally, then the ultimate strength of members under the action of lateral forces becomes of the first importance. Upright members are no longer simply columns, but are more properly considered as vertical beams carrying some initial load, and, viewed in that light, must have all the essential elements of a good beam. The unequal straining and successive failure of the rivets, due to their unsymmetrical distribution in the connections, may become an important element of the design when the stresses are sufficient to overcome the averaging effect of the frictional resistance. The relative values of the ultimate or elastic-limit stresses may suggest details at the connections somewhat different from those indicated by the fixed ratios of assumed working-stresses.

A brief analysis of possible results applied to the definite circumstances and conditions of any particular building may suggest probable failure along one or several well-defined lines, and as readily suggest modifications that will materially increase the strength of the structure, or at least define and limit the amount of destruction.

The amount of metal required for an efficient system of wind-bracing is but a small part of the weight of the metal in the entire frame, and the cost of the latter is only about 10 per cent to 20 per cent of the expenditure for the entire building, exclusive of the site. The cost of the wind-bracing can represent, therefore, only a very small proportion of the total capital invested. When it is considered that any additional metal used to strengthen the cage as a precaution against wind-force is equally effective against possible damage due to earthquake shocks, or to the unequal settlement of the foundations, and is also an additional margin provided against the weakening effect of corrosion, the slight increase in cost must appear trifling as compared to the amount of the entire investment and the additional protection secured for the property.

It is somewhat unfortunate that the merits of the design of the framework are not so readily apparent to the investor, and that this part of the structure is of necessity immediately covered and permanently concealed from view. If the difference in strength and security due to the construction of the frames of some of these great buildings were as generally evident, as, for instance, the difference in strength due to the varying thickness of solid masonry walls was in older forms of construction, there would probably be a more general recognition on the part of the owners of the need of securing the best type of framework.

A discussion of the safety of high buildings is applicable to other high structures, such as chimneys, shot-towers, water-towers, etc., and suggests that the development of the cage construction in buildings to its present advanced type makes it equally available for other structures of the kind named above. Monuments built with no consideration of expense will find ample security in their weight, but for any high structure in which cost and security are both of importance, the cage type of construction is thoroughly applicable and may have special advantages. The saving of material in the walls, and particularly in the foundations, may more than equal the additional cost of the steel work when designed for the same strength and security. The objection to any open tower built of structural metalwork in a city, on the score of its inherent ugliness, is removed by adopting such treatment as the architects have developed in the design of high office-buildings. Any shaft or high structure that has lines of stability can be readily supported on a steel cage that will not interfere with its outlines, with probably a great gain in safety.

The amount of wind-pressure to be provided for in the design of high buildings will no doubt be variously estimated, depending on the weight given in the judgment of the designer and of the owner of the building to the probability of exposure to such pressures. The statistics as to the frequency of tornadoes show that the possibility of their occurrence cannot be entirely disregarded without assuming some appreciable risk. While the atmospheric conditions which are favorable to their formation are more common in some regions than others, it is impossible to feel assured of entire immunity from their occurrence in any city. Tornadoes usually occur as local manifestations accompanying severe storms of great extent. On the date of the Louisville tornado there were ten others in the four adjacent States. On April 11 and 12, 1893, there were nineteen tornadoes in ten States attending severe storms, reaching from Mississippi to Michigan. The St. Louis tornado was but one of a number accompanying a general storm that moved through Missouri and Illinois. As far as known it was not more violent than many others that have been observed. Its great destructiveness was merely incidental to the fact that its path crossed a territory embracing a large and closely-built city. It gave evidence that wind-pressures existed at least equivalent to or greater than 20 pounds, 58 pounds, and 85 to 90 pounds per square foot over considerable areas. Whatever the actual distribution may have been, the effects were those of such pressures uniformly distributed over the areas of the respective structures. These pressures were measured by their results in exactly the same manner in which they are ordinarily assumed to act, with the consequent elimination of all uncertainties usually involved in readings of pressure-gauges or deductions from anemometer records, and they are to that extent positive and definite. In addition, there were indications that a pressure of somewhere from 20 to 40 pounds was quite general over a comparatively wide area in, or adjacent to, the path of the storm, and that the pressures at higher altitudes were more severe than those measured.

In view of these facts it appears to the author rational to assume:

First.—That the safety and interests of the community and of the owner of the building require a recognition of a wind-pressure of at least 30 pounds per square foot against the exposed surface of the building, with an additional local provision of 50 pounds for several stories near the top; and that this amount should be safely taken care of by some positive and definite provision in the construction of the frame.

Second.—That the vast interests at stake, the amount of capital invested and the comparatively small additional expense necessary would suggest to the owner the desirability of increasing the provision to 40 pounds per square foot.

Third.—That the other uncertain elements of safety due to the ultimate strength of the material, the inertia of the mass, and the bracing effect of walls and partitions, should be recognized only as providing against the uncertain and possibly higher pressure of the wind which may occur.

The chief justification of much that seems bold or questionable in the construction of some high buildings lies in the fact that, as yet, none have failed. If the safety of such great structures is to be determined entirely by the logic of the fitness of the survivor, based on a brief and favorable experience, rather than by a rigid analysis, by tried and accepted principles of engineering design, it may ultimately lead to some very deplorable results.

By such a test the little summer pavilion in Lafayette Park must take precedence over the approach to the Eads Bridge, for it survived the tornado and is standing yet.

FIREPROOF CONSTRUCTION IN THE PITTSBURGH FIRE.[1]

THE destruction of several fireproof buildings in the recent fire at Pittsburgh, Pa., may confidently be expected to bring up for discussion again the old question of the efficiency of modern fireproofing systems. Probably, indeed, the reason the disaster has not already received more attention in this regard may be attributed to the fact that outside of a very limited circle, the real story of its character and extent is not known. Although such a discussion means much rethreshing of old straw, it is very desirable that it should be had, for there is yet a great deal to be learned by architects, builders and engineers, not only about fireproofing systems, but also concerning the broader and more neglected subject of protective construction against fires. It is because of these facts partly that *Engineering News* has been at some trouble to collect the evidence regarding the Pittsburgh fire and its effects, and to present it in such a form as will enable its readers to determine its significance and bearing upon the important question of fireproof construction.

The story, as told, may be summed up in a few lines as follows: A fire starts in an old type of brick and wood, slow-combustion building filled with highly inflammable material, and before its progress can be checked it sweeps over an area of nearly two city squares, destroying property to the amount of $3,000,000. Within this area, besides the first-mentioned building, there were three modern fireproofed, steel-skeleton buildings, and a half-dozen small shops and dwellings of ordinary brick and wood construction. When the flames had completed their work there remained of two of the fireproof structures only the outer walls and shattered floor-arches held together by the steel frame, the third fireproof building had five of its eight floors swept nearly clean of their contents and their dividing walls and partitions injured beyond repair, and the brick and wood shops and dwellings were simply heaps of masonry.

To a hasty observer the evidence thus briefly stated will doubtless seem a serious indictment of the much-argued advantages of fireproof building construction, and a very considerable number of people may be expected to take just this hasty view. To the architect and engineer, however, who studies the evidence more carefully in its details, we believe that it should suggest a far different conclusion, and as the duty will fall upon these more expert observers to set aright the views of their clients, it will be time well spent to analyze somewhat carefully the data presented.

Considering the evidence in its general aspects first, several facts of broad significance attract attention. The rapid progress and the intensity of the fire are especially evident. The reasons for this are not far to seek, being evidently the presence of vast quantities of inflammable material upon which the flames could feed and the open exposure of these combustibles to easy ignition, especially in the Horne store and office-buildings. Indeed, there seems to be some irony in calling buildings fireproof which oppose hardly anything to a fire from across the street more sturdy than plate-glass. In the Horne store, too, after the flames had gained access through the open front, there were no dividing partitions to delay their progress, and even the different floors were open to each other by a large light-shaft and several smaller vertical openings. Indeed, the conditions in this structure could hardly have been made more favorable for the rapid spread of the flames. Given such conditions, it is obviously only a question of sufficient fuel to feed it for a fire to destroy any fireproofing.

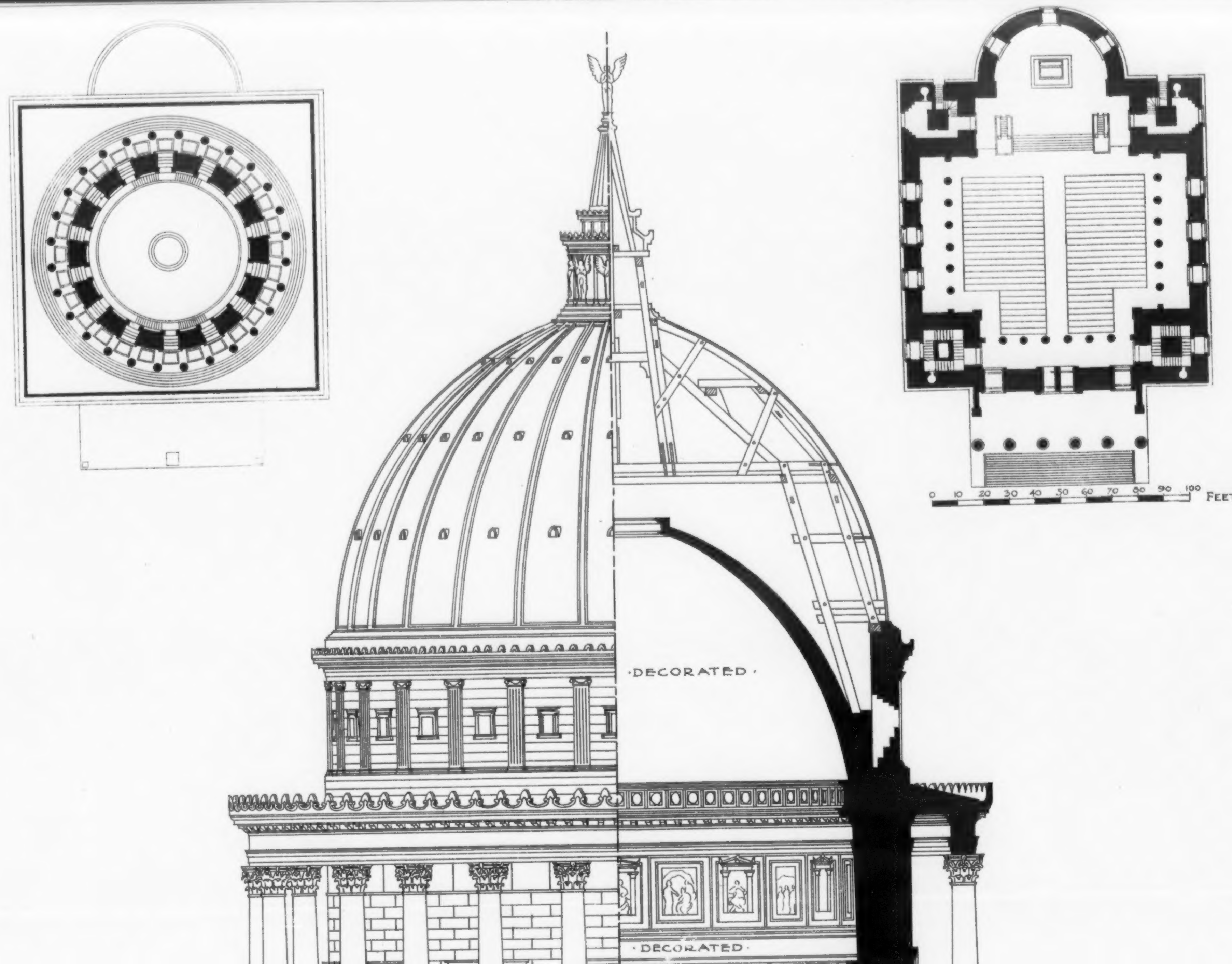
Turning now to the adjacent office-building, it will be noticed at once that the provisions against the spread of fire were somewhat better than in the store-building. The front exposed to the fire was fully as weak, it is true, but there were dividing partitions both transversely and longitudinally above the first floor, although not very strong ones, and fewer and smaller vertical openings. It is reasonable to assume that these facts account in some measure for the better condition of the fireproofing, although doubtless the smaller stock of combustibles and possibly the use of porous tile and the end construction of the floor-arches also contributed to the more favorable result. Another fact which is of interest in connection with the fire in this building is that the flames appear to have passed along the first floor, which was open to the rear, and then to have ascended the elevator-shaft and the stairway to the rear rooms of the floors above. The building was thus attacked by the flames nearly simultaneously in the front and the rear.

Before proceeding further it is well to consider for a moment what the lesson is that is taught by the general facts previously outlined. It seems to us to be simply that the protection of buildings against fire does not stop with the rearing of a steel skeleton and clothing it with an integument of incombustible and non-conducting material; but includes impervious outer walls, with a minimum of window and door areas, and these protected by fireproof shutters, frequent dividing-walls, and inclosed elevator-shafts, stairways and similar vertical openings. A provision for fighting fire is also an important consideration, although in a fire like the one under consideration, occurring in the night and spreading so rapidly as it did, there is very little opportunity to use the ordinary building hose and hand grenades.

A second fact of prime significance in connection with the fire as a whole is that the three fireproof buildings, namely, the two Horne buildings and the Methodist Book Building, established the boundaries to the progress of the flame in two directions. In this respect, at least, they proved of inestimable value, since if the fire had once passed them it would have had a fertile field of small buildings filled with lumber and combustible merchandise to feed upon. The question may with reason be asked here: why, if these buildings furnished so little opposition to the flames at their fronts, did they so efficiently restrict their passage at the rear? The answer to this question is evidently found in the fact that in the Methodist Book Building and the Horne office-building the rear walls were of brick and without windows, while in the Horne store-building the rear wall had a small window area as compared with the front, and all windows were closed with fireproof shutters. It seems the irony of fate almost, that these very shutters which had been built to protect the store-building from its apparently more dangerous neighbor should have served at their first trial the opposite purpose of saving that neighbor from destruction.

But not to stray too far from the main thought, let us see just what the efficiency of these protections proved to be. As already noted, the fire did not pass to the building adjacent to the windows covered by them. Further than this, investigation showed that while the window-framing and the merchandise adjacent to it were in ashes, none of the shutters had been burned through. Only one shutter was seen which seemed to have been burst open by the fire

[1] From *Engineering News*.



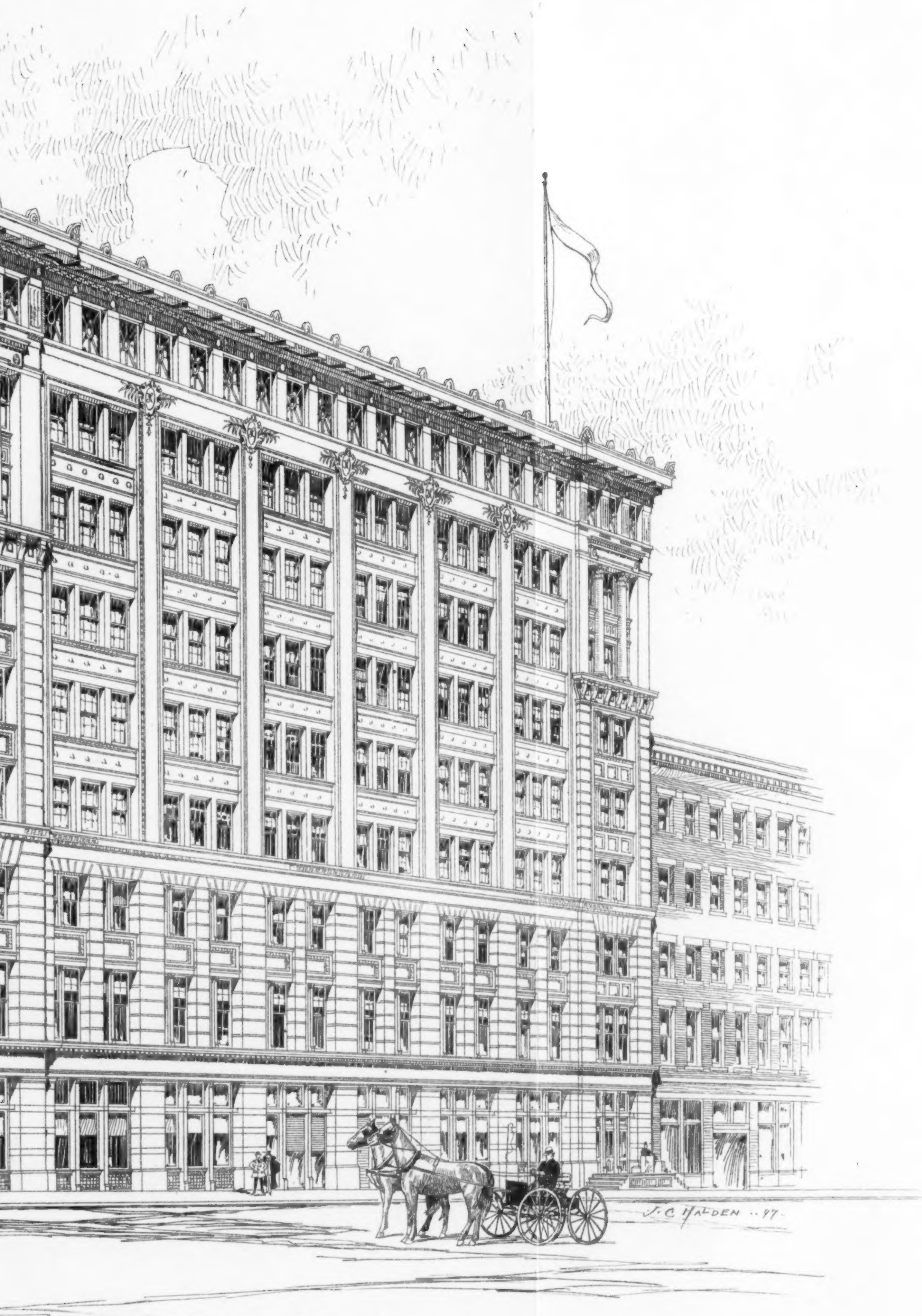
0 10 20 30 40 50 60 70 80 90 100 FEET.
·DECORATED·
·DECORATED·

RENAISSANCE DOMES, No. 8: THE NICOLAIKIRCHE, POTSDAM, PRUSSIA.

AMERICAN ARCHITECT AND BUILDI

STORE AND FACTORY BUILDING FOR HENRY HEIDE, ESQ., HU

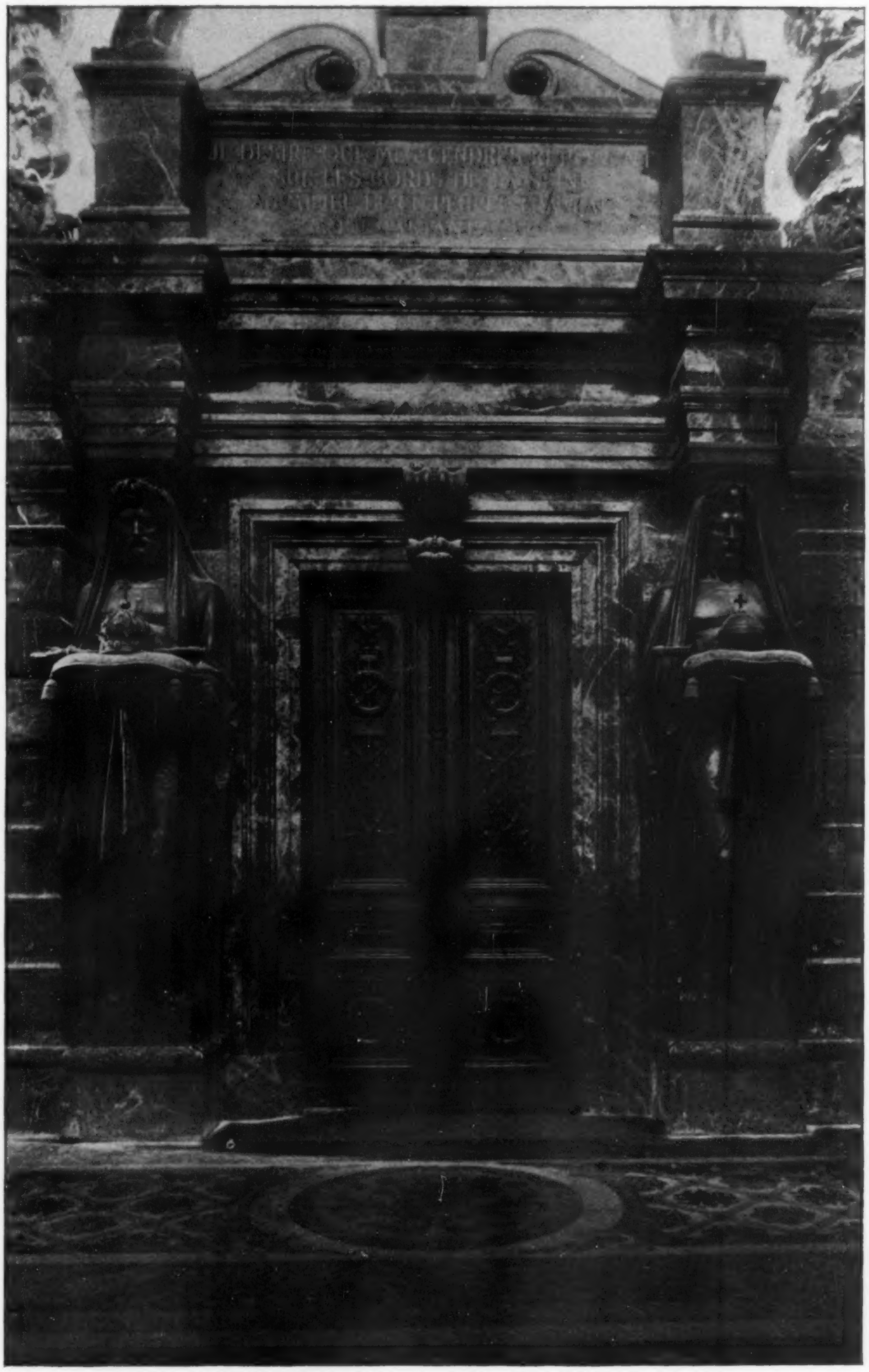
DE LEMOS & CORDES, ARC



...Q., HUDSON AND VANDAM STREETS, NEW YORK, N. Y.

...ES, ARCHITECTS.

Doors and Doorways, No. 3:—Entrance to the Old Episcopal Palace, Frejus, France.



Doors and Doorways, No. 4 :—Entrance to the Tomb of Napoleon,
Chapelle des Invalides, Paris, France.

L. T. J. Visconti, Architect. F. J. Duret, Sculptor.

or the attack of the firemen upon it, although all were more or less warped. The heat to which these shutters were subjected, however, must have been very intense, for only a few feet from them were found masses of half-melted crockery and glassware and the distorted tubing of bicycle frames. These tests were certainly crucial ones and that they were so successfully withstood speaks stoutly for the value of fireproof shutters.

Unfortunately this favorable evidence cannot be supplemented by any very reliable records of the action of the shutters on the Cecil Alley side of the Jenkins Building, as this wall fell early in the conflagration and only the evidence of more or less unreliable eye-witnesses of the fire is available for consideration. According to one report in a local newspaper, these shutters held until heated to a white heat and did not permit the flames to pass, but how much longer they remained effective is nowhere stated. It is a fact, however, that the Methodist Book Building, directly opposite these windows, was the last of the larger buildings to take fire. but this was doubtless due, to a considerable extent, to its smaller exposure of window area, so that the existence of shutters on the Jenkins Building cannot be positively asserted to have been the cause of its later ignition. The evidence, we think, may be pretty justly summarized by stating that nothing can be said unfavorable to the efficiency of these shutters, while a good deal can be said in their favor.

Passing to a consideration of the damage done by the fire to the more purely structural features of the several buildings, one is impressed at once with the splendid showing made by the steel frames. Not a single steel member can be said to have been torn from its position in the structure by the heat of the fire or the destruction of its protecting fireproofing. In the Horne store-buildings at least 50 per cent of the columns and floor-beams were found partly or wholly uncovered, but only slight bends were found in two or three columns. The thing responsible for the damage to most of the injured steelwork in this building was the fall of the heavy steel water-tank from the roof, and this accident seems to have been due to the reprehensible construction of the tank-supports on the roof, which were of wood that burned away and allowed the tank to crush onto the light roof framing. The steel-work in the Horne office-building showed no injury except for occasional bent floor-stringers, and that in the Methodist Book Building did not seem to be injured at all.

These facts appear to us to be very significant. Much has been said at one time and another regarding the horrible distortion which might be expected should one of our modern steel skeleton structures be subjected to an extensive fire, and it is very gratifying to have these assurances refuted by practical test, if only to the extent afforded by the Pittsburgh fire. It will probably be contended by no one that expansion and contraction did not occur, perhaps to a greater extent than the uncovered framework indicates, but it can be asserted that the danger of wholesale destruction from this cause does not seem to be very great. Despite all this, however, it must be borne in mind that these Pittsburgh structures had large lateral dimensions and no very great height in comparison, and also that a very high character of steel-construction was used. A similar fire in some of our chimney-like metropolitan office-buildings might mean a far different result.

When we turn to the action of the fireproofing protecting the steel, we find the results of the fire somewhat more difficult to analyze. In each of the three buildings a different kind of fireproofing material was used and in each the intensity and progress of the fire itself varied. It is hardly fair, therefore, to assume from the appearance of the ruins alone any special excellence for any one kind of fireproofing as compared with the other. There is no very good reason to doubt, however, that the heat was most intense in the Horne store-building, less severe in the Horne office-building, and least trying of all in the Methodist Book Building. The damage to the fireproofing in these three buildings ranks in severity about in the same order. Between the Horne store and office buildings the difference in the intensity of the fire was the least, undoubtedly, and it may be reasonably assumed that the better action of the fireproofing in the office-building was due, to some extent, to the use of the porous tile and the end construction of the arches. This rather upholds the very general opinion that the porous tile and the end construction is superior to hard tile and side construction.

A particular feature to be remarked is that no particular part of the fireproofing seemed to resist the fire better than another; the column tile, the floor arches, and the beam-flange covering seeming to have been destroyed about equally. In the office-building, where partitions were used, their destruction was pretty serious, as might have been expected. No very great stability against fire and streams of water can be expected from partitions of four-inch tile, and the wonder is that they stood as well as they did. In respect to their efficiency, however, there does not seem to be much choice between partitions of four-inch tile and the metal lath and wooden stud partitions used in the Methodist Book Building, and the builder who pins his faith to either to resist a severe attack of fire and water is likely to be disappointed.

The behavior of the sixteen-foot span concrete floor-arches in the Methodist Book Building must, we believe, be conceded by every fair-minded man to have been most excellent and to justify the faith which many architects and engineers have shown in concrete floor constructions. It is true that the heat to which they were exposed was not as great as that in the buildings with the tile construction; but it is also true that many of these concrete arches were in the midst of a very severe fire for a considerable time, and came through it, with hardly an exception, absolutely unharmed. We believe that the Pittsburgh fire adds convincing evidence to that already accumulated in engineering literature, that concrete is entitled to rank as a material of the highest value in fireproof construction.

In what has preceded will be found some of the suggestions which the fire at Pittsburgh seems to offer to architects and engineers, and doubtless others will be found. To such experts we may confidently entrust the evidence for a fair consideration, but the general public will hardly lay so much stress on these finer points and will want an unqualified answer to the question, whether the Pittsburgh fire did or did not prove the uselessness of fireproof construction? It may be answered at once that it proved the value of such construction, if for no other reason than that these fireproof buildings prevented the spread of fire beyond them. It is true that the business man may see little inducement to fireproof construction if it means loss on the fireproof building and safety beyond it, but he can also see that if the fronts of these burned buildings had been as well protected as their rears, the fire would have had serious difficulty in ever entering them. Just here is the thing that the average builder has been prone to overlook. He will go to great expense to make his building incombustible, and then, for reasons of economy, or to display his goods, or to gain some other end which he desires, he will stop short of making it reasonably inaccessible to fire. The three fireproof buildings at Pittsburgh were destroyed by an exposure fire, and they could have been hardly more open to the access of such a fire if their whole fronts had been lacking.

We are not overlooking the fact that buildings must be suitable for occupation and business and, therefore, must have doors, and windows and stairways, but these can all be had and the openings still be protected in such a manner as not to afford free access to flames and heat. For example, there was no structural reason why the windows of the Horne store and office buildings at Pittsburgh should not have had rolling steel shutters, and if they had, is there much question but that the firemen from inside these buildings could have saved both from serious damage? It is needless to go further into the consideration of what might have been done, for enough has been suggested, we think, to show that any wholesale condemnation of fireproof construction, when we consider it in its broad meaning of protective construction against the spread of flame, is not warranted by the Pittsburgh fire and its results.

In a closing word, attention may well be called to the fact that modern fireproofing systems have never before been subjected to so severe a test as in the Pittsburgh fire, nor has it ever before suffered such wholesale destruction by fire. In order that those interested may compare this fire with others in which protective fireproofing has been attacked, we append as a footnote a reference to all such disasters as have been described in *Engineering News* during the past five or six years.[1]

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.*]

NEW YORK LIFE INSURANCE BUILDING, CHICAGO, ILL. MESSRS. JENNEY & MUNDIE, ARCHITECTS, CHICAGO, ILL.

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

RENAISSANCE DOMES, NO. 8: PLANS AND SECTION OF THE NICOLAIKIRCHE, POTSDAM, PRUSSIA.

THE body of this church, built 1830–37, was designed by Karl Friedrich Schinkel in collaboration with Ludwig Persius. The dome was built (1842–50) by the architects Stüler and Prüfer.

STORE AND FACTORY BUILDING FOR HENRY HEIDE, ESQ., HUDSON AND VANDAM STS., NEW YORK, N. Y. MESSRS. DE LEMOS & CORDES, ARCHITECTS, NEW YORK, N. Y.

DOORS AND DOORWAYS, NO. 3: ENTRANCE TO THE OLD EPISCOPAL PALACE, FREJUS, FRANCE.

DOORS AND DOORWAYS, NO. 4: ENTRANCE TO THE TOMB OF NAPOLEON I, CHAPELLE DES INVALIDES, PARIS, FRANCE. M. L. T. J. VISCONTI, ARCHITECT; M. F. J. DURET, SCULPTOR.

THE two colossal figures that flank the bronze door represent, respectively, "Military and Civil Force."

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

ACCESSORIES OF LANDSCAPE ARCHITECTURE, NO. LVII: A GROUP OF ENGLISH GARDENS.

[1] **Exposure fire: Schiller Building, Chicago, Ill.,** *Engineering News*, **April 9, 1896; interior fire: Temple Court Building, New York,** *Engineering News*, **April 13, 1893, April 9, 1896; interior fire: Athletic Club Building, Chicago,** *Engineering News*, **December 1, 1892, April 9, 1896; exposure fire: Manhattan Bank Building, New York, November 14, 1895.**

RENAISSANCE DOMES, NO. 7: THE NICOLAIKIRCHE, POTSDAM, PRUSSIA. ARCHITECTS: SCHINKEL AND PERSIUS; STÜLER AND PRÜFER.

[Additional Illustrations in the International Edition.]

THE RIDDAREHUSET (HOUSE OF KNIGHTS), STOCKHOLM, SWEDEN. SIMON AND JEAN DE VALLÉE, ARCHITECTS.

[Gelatine Print.]

This imposing building stands upon a fine open square, with its palatial front facing south. It was erected from the plans of Simon de la Vallée, a French architect, who, after having been employed for a time in Holland by Prince Frederick of Orange, accepted a call to the Swedish capital about the year 1637, when Queen Christina, daughter of Gustavus Adolphus, was but eleven years old. The architect, however, was destined not to carry his plans into execution, for he was shortly assassinated in the open street, by Baron Axel Oxenstjerna, his personal enemy. After his death, the charge of the work passed into the hands of Heinrich Wilhelm, a German master, who died in 1652, and was followed by a Dutchman, Joest Vingboons by name, who, three years later, was replaced by Jean de la Vallée (1620–1696), the son of Simon, the designer of the edifice. But not until fifteen years later, in 1671, was the main portion of the building completed. The two pavilions, standing at the north end of the lot and separated from the main building by a fine garden, were erected as late as 1870 after the original plans, drawn more than 200 years previously. The Riddarehuset was erected for the Swedish nobility, the highest of the four states, or orders, representing the people in the diet, viz: nobility, clergy, burghers and peasants. It served as an assembly-hall for the council of the nobles until a Constitution was granted by the Crown in 1865. Since then the building has been used for conventions of an economic, agrarian and administrative character, held by the nobility every five years. It is also used for other meetings and conventions.

PULPIT IN TRIER CATHEDRAL, RHENISH PRUSSIA.

[Gelatine Print.]

The pulpit in the Trier Cathedral, a characteristic specimen of the German Renaissance style, is the work of Hans Ruprecht Hoffmann, dating its origin from the year 1572. The main body of the pulpit, which is of carved white and black marble, is placed against one of the big cross-shaped pillars of the transept, while the steps leading up to it occupy one of the re-entrant angles of the same. The sculptured reliefs of the balustrades of pulpit and stairway represent the various works of mercy. The steps are reached through a portal which for elaborateness of decoration is probably unique. The heavy cornice over the archway is surmounted by statuettes of winged angels, supporting heraldic ornaments, while the central feature contains a fine relief, representing Christ rising from the sepulchre. The sculptured work shows throughout a high degree of perfection.

THE CHURCH PORCH, CLEY-NEXT-THE-SEA, ENG. DRAWN BY MR. W. H. OAKLEY.

ENTRANCE-HALL FOR MESSRS. FOSTER & COOPER, NOTTINGHAM, ENG. MR. A. MARSHALL, ARCHITECT.

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.*]

CONCRETE FLOORS AT THE PITTSBURGH FIRE.

Brooklyn, N. Y., May 21, 1897.

To the Editors of the American Architect: —

Dear Sirs, — I notice in the first editorial in your issue of May 15, commenting on the great fire in Pittsburgh, that you make the statement that the Horne Building destroyed, was built of protected iron and *concrete*.

You have, no doubt, unwittingly, done concrete construction an injustice in this statement. As a matter-of-fact the Horne Building was constructed of flat tile arches, and the columns and girders throughout were protected by the same method. On the other hand, the Methodist Book Building which was constructed throughout with concrete floors withstood the action of the fire wonderfully. The woodwork partitions and all the contents of the five floors were burned out, but the concrete floors were entirely uninjured.

The *Engineering News* of May 20 contains a full account of the fire, with photographic illustrations showing the methods of construction involved.

Leaving aside the question of superiority of one method over another, it is certainly an injustice to state that the destroyed building was constructed of concrete fireproofing, when, as a matter-of-fact, the concrete fireproofing was the most successful construction involved.

I am familiar with the construction of both of these buildings, and feel sure that you will be glad to correct the statement to agree with facts. Very truly yours, Jno. T. Simpson, *Engineer.*

[We are glad to have our correspondent correct our misstatement. — Eds. American Architect.]

NOTES & CLIPPINGS

A New Use for the Paris Catacombs. — A new and essentially nineteenth century use has been discovered for the catacombs by which the sub-soil of Paris is honeycombed. The subterranean galleries of this kind beneath the Jardin des Plantes have now been converted into a species of laboratory and aquarium. A number of them have been fitted with reservoirs and glass tanks, while in others the niches that once contained human bodies have been converted into cages, where scientists are able to study the effect of total and partial darkness upon animal life. — *N. Y. Tribune.*

Water-tanks in Church Towers. — Mr. J. C. Merryweather, the well-known manufacturer of fire-apparatus in London, makes a most useful suggestion on the subject of the protection of churches from fire. After referring to the dangers of fire in such buildings from defects in the heating and lighting apparatus, he proposes that each church tower should be fitted with a tank or tanks, kept full of water by means of a pump and hose or fixed pipe, the pump to take supply from a well or other available source. From the tanks he suggests a pipe being carried into the church, with hydrants and hose in convenient positions. The water-tanks would then enable powerful jets to be brought to bear immediately an outbreak of fire was discovered. The cost of the arrangement would be small, and doubtless the destruction of many sacred buildings by fire would be prevented. Canterbury Cathedral has been saved three times by its own fire-apparatus, and the recent fire at St. George's, Hanover Square, proves that even in London there is considerable risk of fire in places of worship. — *Fire and Water.*

The Storage of Dynamite. — In 1893 the French Government appointed a committee to investigate and report on matters connected with the storage of dynamite in quarries and mines, particularly with reference to the isolation of the effects of any accidental explosion. This committee, from a number of experiments on a small scale, were led to the conclusion that there was no difficulty in constructing either a surface or an underground magazine so as to insure practical safety, but their resources did not permit of them testing these conclusions on a practical scale. Owing to the public spirit of the Comité Centrale des Houillères de France and of the Compagnie des Mines de Blanzy, this objection was removed, and experiments made with very large charges of dynamite. In the first of these, carried out at Blanzy, the magazine was sunk about 66 feet below ground. It was T-shaped, the table of the T forming the magazine proper, which measured 33 feet by 6 1-2 feet high by 8 feet wide. Half a ton of No. 1 dynamite, containing 70 per cent of nitro-glycerine, was packed here, the density of charge, denoted by weight of dynamite in kilogrammes ÷ volume of magazine in litres, being = 1-100, reckoning the volume of the magazine proper only. If, however, the access galleries were included, this density would be reduced to 1-200. This access gallery, representing the stalk of the T, was of circular section, and 5 feet in diameter for the most of its length. At one point, however, it passed through a large block of concrete, in the middle of which it was abruptly reduced to a diameter of 3 feet 3 inches. The shoulder thus formed served as a seat for a plug 5 feet in diameter, and about 5 feet thick, completely filling the access passage, but standing normally about 6 feet away from the seat provided for it, as above explained. This plug was made of millboard and soft wood. Into the space thus left between the shoulder and the plug opened a side gallery, giving access to the magazine around the plug. This passage having two right-angle bends and a blind pocket, an explosive wave would take an appreciable time to pass through it, and thus time would be obtained for the plug to be driven on to its seat, and seal the magazine by completely closing all outlet. On trial this arrangement was found to work perfectly. A wagon left immediately in front of the access gallery was quite unaffected by the explosion, and some seconds elapsed before any smoke issued into the gallery. On clearing the latter by a hand-ventilator, it was found that the force with which the plug had been driven on to its seat had jerked off some fragments of wood and paper which were flung down the passage, but otherwise the damage was insignificant. From this experiment it was concluded that the system described could be adopted quite safely for even larger stores of the explosive. Other experiments made on a nearly equally large scale had reference to shallow magazines. In one case one-fifth of a ton of dynamite was placed in a magazine excavated in sand at a depth of only 15 feet below the surface, and communicating through a lateral passage 80 feet long with an open cutting 22 feet to 26 feet deep. The density of charge was 1-50, reckoning the volume of the magazine proper only, or 1-200 if the access passage was taken into account. On exploding the charge, the soil above was lifted to a height of nearly 3 feet, but there was no projection of matter, nor did any gases escape in this direction. Practically the whole force of the explosion seemed to be expended on the access passage, the timbering of which was driven out with great violence, but the damage done could, it appeared, be quite easily localized. The committee did not, therefore, consider it necessary that magazines should be constructed so that an explosion might show absolutely no external effects, but considered that each case should be treated on its merits, hard and fast regulations being avoided. — *Engineering.*

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