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Edited by Edwin O. Sachs.

THE TALL BUILDING

UNDER

TEST OF FIRE.

BY

H. DE B. PARSONS.

With Illustrations.

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OBJECTS OF THE COMMITTEE:

The main objects of the Committee are:—

To direct attention to the urgent need for increased protection of life and property from fire by the adoption of preventive measures.

To use its influence in every direction towards minimising the possibilities and dangers of fire.

To bring together those scientifically interested in the subject of Fire Prevention.

To arrange periodical meetings for the discussion of practical questions bearing on the same.

To establish a reading-room, library and collections for purposes of research, and for supplying recent and authentic information on the subject of Fire Prevention.

To publish from time to time papers specially prepared for the Committee, together with records, extracts, and translations.

To undertake such independent investigations and tests of materials, methods and appliances as may be considered advisable.

The Committee does not hold itself in any way responsible for the opinions expressed, or methods advocated, by members and others who kindly contribute to these publications.

Comments on the opinions expressed in these papers, or further information on the subjects under consideration, are cordially invited by the Executive, at whose discretion they will be circulated among the members of the Committee.

The Committee's Reports on Tests with Materials, Methods of Construction, or Appliances are intended solely to state bare facts and occurrences, with tables, diagrams, or illustrations, and they are on no account intended to read as expressions of opinion, criticisms, or comparisons.

NOTE.

The fire which occurred on the 17th inst. in the Hyde Park Court Mansions should remind the Londoner that he also has some of those "Tall Buildings" which are such a menace as far as danger to life from fire is concerned.

Only last December we heard of a serious fire of this description in the Home Life building at New York, which was caused by the spreading of an outbreak from some adjoining property. But, as is generally the case with us regarding things American, we did not give much attention to the lessons which this conflagration taught us, no doubt thinking the "Tall Building" fire to be a speciality reserved for the United States.

Again, but a few weeks back, we had the terrible fire at the Hotel Windsor, New York, with its fearful death roll, and though the lessons from an old hotel building may not be directly applicable in the case of the "Tall Building" of recent date, yet we should remember that in this Metropolis it is just the large hotel and the large block of flats which take the dangerous form I speak of, whereas the number of high office buildings is still very small.

That this Committee should have been able at such short notice after the Hyde Park Court fire to put before its Members a carefully prepared paper entitled "The Tall Building under Test of Fire" is due to the great courtesy with which the editor of the "Engineering Magazine" has met the request of the Executive to reproduce an article which was prepared for that journal by Mr. H. de B. Parsons, and I need hardly say that I am glad to take the opportunity to express my thanks for the kind assistance afforded to this body.

Though we do not as yet quite appreciate it, the risk of the "Tall Building" is already a very serious one in London, and calls for close attention, all the more as our means of fire-fighting and life-saving have not been organised with the particular purpose of meeting the "Tall Building" risk, and our water supply can also scarcely be said to adequately fulfil such special calls.

EDWIN O. SACHS.

LONDON,

18th April, 1899.

The Tall Building under Test of Fire.

By H. de B. Parsons.

(A Paper prepared for the "Engineering Magazine.")

The modern "sky-scraper" presents many problems, but none more generally interesting than the question of its security against fire. The picture below shows the result of the careless dropping of a lighted match. The photograph presents the ruins of the Burdette Block, in Troy, N.Y., which was wrecked by fire on February 17, 1896. The building was erected in the ordinary manner, with brick walls and wooden floors. So rapidly was it

FIG. I. RESULTS OF A FIRE IN TROY, N.Y.

consumed that four lives were lost, although the fire took place in the day-time. Buildings of this class are totally unable to resist fire.

Many imagine that, because iron and steel are incombustible (in the common acceptation of the word), buildings constructed of such material, together with bricks, cement, and glass, may be classified as fire-proof. The construction of a building out of materials in themselves non-combustible does not produce a fire-proof structure. Fig. 2 represents the ruin of the Quinsigamond mill, Worcester, Mass., caused by fire on April 5,

FIG. 2. RUINS OF QUINSIGAMOND MILL, WORCESTER, MASS.

1896. This building was erected on the independent plan, a steel frame supporting the floors and roof. The columns were of built-up steel, carrying floor-beams of the same material. The window-boxes were of steel, and the walls were of brick built in between the frames so as to enclose the whole. Wood was used for the flooring on the "slow-burning" plan. The photograph very clearly shows the result; how could the destruction have been more complete? The building was entirely gutted, and the columns and beams were twisted into an entangled mass. Witnesses of this fire state that the columns began to yield from fifteen to twenty-five minutes after the fire started, although the floors were not heavily loaded. Had this building been erected on the "slow-burning" principle, it would have resisted the fire much longer. In this type of construction heavy wooden columns and girders are used, which retain for a considerable time, when subjected to fire, sufficient strength to carry their super-imposed loads, permitting the escape of the occupants, the saving of valuables, and the arrival of assistance. Such examples show that plans for all buildings in crowded districts should be intrusted only to the best of designers.

The design would be much simplified if there were no fear of fire. What constitutes a "fire-proof" structure? The term "fire-proof" has become generic, and is in many instances a misnomer. In its usual sense it is used to designate a certain style of modern structure that has become very popular. Structures of this type rely, for their stability, support, and fire-resisting properties, on the steel and iron skeleton frame and on the other non-combustible materials used.

It has been repeatedly proven that metal construction cannot withstand fire, unless well guarded. No matter how "fire-proof" a building may be, it will be ruined, if sufficient combustible material is stored within to create a hot fire lasting for a considerable time.

Manufacturers have produced many forms of fire-proofing protection, and have striven to obtain something that will not burn. Architects and engineers have given too much attention to the substance of which the fire-proofing has been made, and not enough to its proper application. It is, however, fortunate that the present tendency is in the direction of protecting the metal skeleton as a primary object, since upon it the self-sustaining properties of the whole structure depend. It should be a secondary object to so sub-divide the floors as to confine the fire.

Without injuring the usefulness or the efficiency of the building, the amount of combustible material now used could, by careful planning, be reduced. In the ordinary American office building wood-work is commonly used to a much larger extent than generally supposed. Taking as an instance a ten-story building of recent fire-proof construction, the wood-work in the floors, panels, bases, chair-rails, doors, window frames, and general trim amounted to about two pounds for each cubic foot of contents. This estimate did not include the furniture or movable office-fittings. The total weight of wood was about 1,200,000 pounds, or as much as the weight of the iron frame. In some of the largest and newest buildings the weight of wood-work has been reduced, but there are many in the sky-scraping class in which the wood considerably exceeds the weight of metal.

A number of these tall structures are more vulnerable from fire without than from fire within. The design is often such as to render it difficult for a fire to obtain headway within the building before its discovery, while the same building would be most susceptible to damage if a fire should occur in the immediate vicinity. Designers fail, as a rule, to give due weight to the value of these external hazards. A good example of this is seen in Fig. 3, a photograph of the damage done to the Manhattan Savings Institution Building through a fire on the opposite side of the street. The girders in this building were unprotected, and, failing, permitted the floors to fall.

Some three years ago a joint committee, representing the insurance, architectural, and engineering interests, made some elaborate tests of the effect of fire on full-sized metal columns, finding that such columns failed when heated to a faint red color, representing a temperature of about 1,200 degrees F. The steel columns buckled at the centre, while the cast-iron ones bent, snapping, if not relieved of their load, when the amount of deflection began to exceed the diameter. The time required to cause destruction varied from 29 minutes to 2 hours, according to the character of the test—a result which agrees very closely with the failure in the Worcester mill. The cast-iron columns were heated to more than 1,100 degrees F., and were then suddenly cooled by

FIG. 3. A FIRE-PROOF BUILDING WRECKED BY A FIRE ACROSS THE STREET.

means of a fire stream. No injurious effect was produced, beyond the cracking of the furnace brick-work.

The result of our knowledge, based on actual experience and on experiment, is that iron and steel cannot support a load when heated to a faint red. The metal must be protected. It will not suffice to have simply a non combustible protecting material; the material must be of such a character that it cannot be disintegrated or dislodged either by water or by expansion. The covering must be so fastened as to remain in place, and such fastening is best accomplished by self-bonding, and not by wiring or similar artificial means. The desire of the owner and real-estate agent to obtain light for halls at the expense of safety, and to economize space by placing the stairs and elevators in the same well, should be strongly restrained.

It has become possible to consider from a practical standpoint this important subject of a fire-proof building versus fire, by taking as an illustration a recent conflagration in New York city. The building in this instance was no doubt much favored in the assistance rendered by one of the most efficient fire departments in the country. On the night of December 4, 1898, a fire occurred in a five-story ordinary brick and wood building, situated on the south-west corner of Broadway and Warren Street, occupied by Rogers, Peet & Co., as a retail clothing store. Adjacent to this, on Warren Street, was another, but smaller, building of similar design, used as an annex. On the south was the comparatively new Home Life Insurance Building, and, next to it, that of the Postal Telegraph Company.

The general appearance of the Home Life Building is shown in the frontispiece and in Fig. 4. It has sixteen stories, and the floor plan is arranged with a light shaft in the middle of the north side. Along this light shaft are the elevators, and next to them is the staircase. The side and rear walls are of brick, while the front is of marble, built solid from the foundations. The building,

FIG. 4. THE HOME LIFE BUILDING (IN COURSE OF RECONSTRUCTION).

with the exception of the front wall, is constructed on a skeleton framework of steel. The walls are lined with 2-inch porous terra-cotta furring. The floor arches consist of 12-inch and 9-inch hollow, hard-burned, terra-cotta blocks, the skew-backs covering, with their soffit extensions, the lower flanges of the steel floor beams. The columns are of steel, built up, H sections, and covered with 2-inch porous terra-cotta furring blocks. The girders are protected on their sides with the same terra-cotta blocks, while their soffits are covered with wire lath and plaster. The upper chords of all the girders, except one on the sixteenth floor, are buried in the floors. The principal partitions are made of 4-inch porous terra-cotta blocks without metal supports. Many of these partitions are not continuous to the ceiling, being finished off with large plain glass transoms set in wood framing. All the windows were of glass set in wood sashes and window boxes. There are no shutters. The finish of the office-floors consists of a wooden floor laid on sleepers placed across the floor beams, and not buried in ashes or cement. The walls and ceilings are plastered. There is a varnished base, chair-rail, window-, door-, and transom-trim.

Within an hour after the fire started, a strong northerly to north-easterly gale was driving the flames from the Rogers-Peet building against the walls of the Home Life Building and into the light well, which acted as a chimney. The fire entered the unprotected windows of the eight upper floors, and found inside a natural draft through the elevator openings. The result was the total destruction of the contents of the upper eight floors, and the saving of the Postal Building by its equally tall neighbor. As a fire stop, the Home Life Building certainly succeeded admirably, for, had it not been there, it is fearful to contemplate what might have resulted during a gale of almost hurricane force. Such buildings are not, however, erected or designed as fire stops, and can be so treated only incidentally.

The vagaries of the flames were as peculiar as ever. In one room where the contents were destroyed a waste-paper basket remained, and in another a towel still hung on a rack unscorched, although the room was totally wrecked. The lower eight stories escaped the fire, but suffered from water.

In the accompanying pictures can be seen the total destruction of the finish of the various floors, nothing being left except the absolute fire-proof material. The plaster work, although not combustible, was absolutely destroyed, and in all of the rooms, from the ninth floor up, there is hardly any plaster left on the walls. The wire lathing used over the pipe chases in the walls and over the various irregularities in the building appears not to have stood the attack of the flames. This may have been due partly to the manner in which it was fastened, but more probably to the fact that the metal expanded sufficiently to throw off the plastering, which has no flexibility. The wood-work used in the finish of the building was not preserved in any of the rooms reached by the fire, except in a few in the rear of the building. In some of these a part of the office furniture still remained, although badly wrecked. In one room on the fifteenth floor a tall wall bookcase still stood. The book-shelves were protected by the closely-fitting books placed upon them, while the books were damaged beyond use. Had these shelves, however, been in the front of the building, they, no doubt, would have been destroyed, as there the fire appears to have been fiercest, probably because there were window-openings on the north wall of the east wing. Those partitions which were cut for the purpose of inserting large transom windows near the ceiling suffered most. The glass in these windows no doubt broke, and permitted the flames to spread from room to room, thus removing the value of these partitions as fire stops.

The accompanying illustrations--Figs 5 to 10 inclusive—convey a clear idea of the ruin accomplished.

The main metallic frame-work was but slightly damaged. A large proportion of the injury seen in the photographs was done by the firemen and the building inspectors, and cannot be attributed to the flames. In Fig. 5 is

FIG. 5. HOME LIFE BUILDING, 9TH FLOOR—THE LOWEST DAMAGED BY FIRE.
The large safe fell from the floor above.

seen a large safe, weighing about 4,000 pounds, which fell from the floor above into a room on the ninth floor, lately occupied by the Rapid Transit Commission. It is reported that the firemen cut a hole in the arch for the passage of a hose, and thus permitted it to fall. Whether this statement be true or not, the ninth floor was sufficiently strong to retain it. The photograph shows the floor beams uninjured.

Fig. 6 shows a view of a room in the front of the

FIG. 6. 10TH FLOOR. COLUMN AND GIRDER COVERINGS AND PARTITIONS INTACT.

Transom windows seen in partition.

building, on the tenth floor. The ceilings and partitions are intact, but the plaster and wood-work were totally destroyed.

The destruction of the wooden flooring throughout the upper stories was largely due to the considerable air-space between the wood and the flat floor arches. This space should not have existed; had it been filled, the floors would have stood much longer.

The effect of using other material than wood for flooring is plainly illustrated in the various halls, which were subjected to an enormous heat. The flooring of the halls was made of mosaic blocks. These blocks retained their position, and the floors were practically

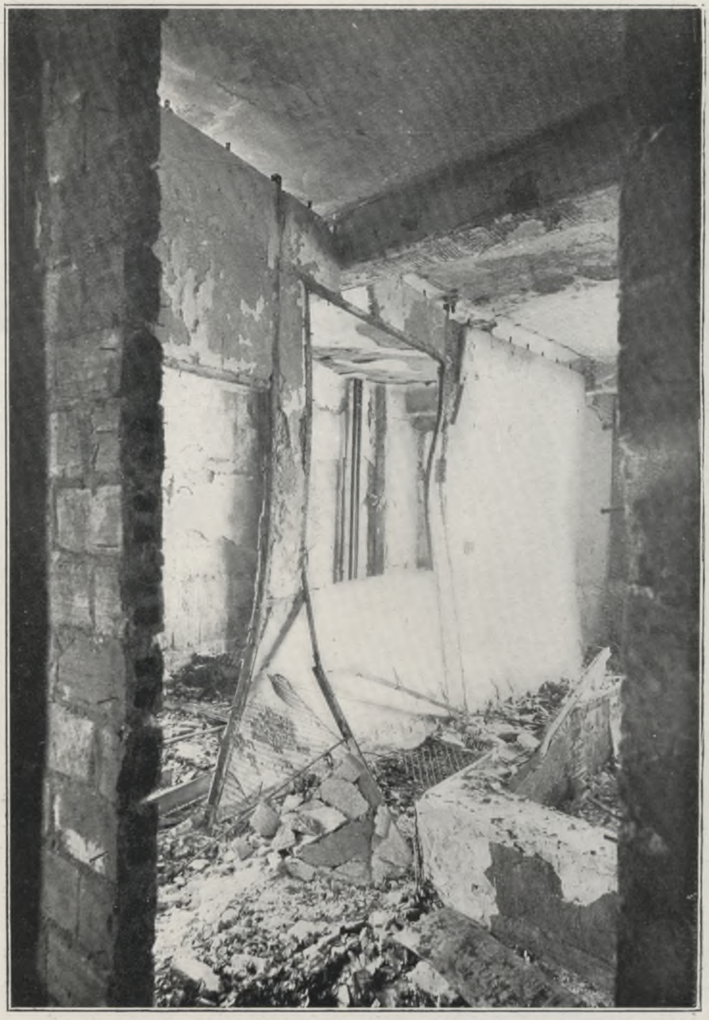

FIG. 7. 12TH FLOOR, FRONT, SHOWING A PARTITION.

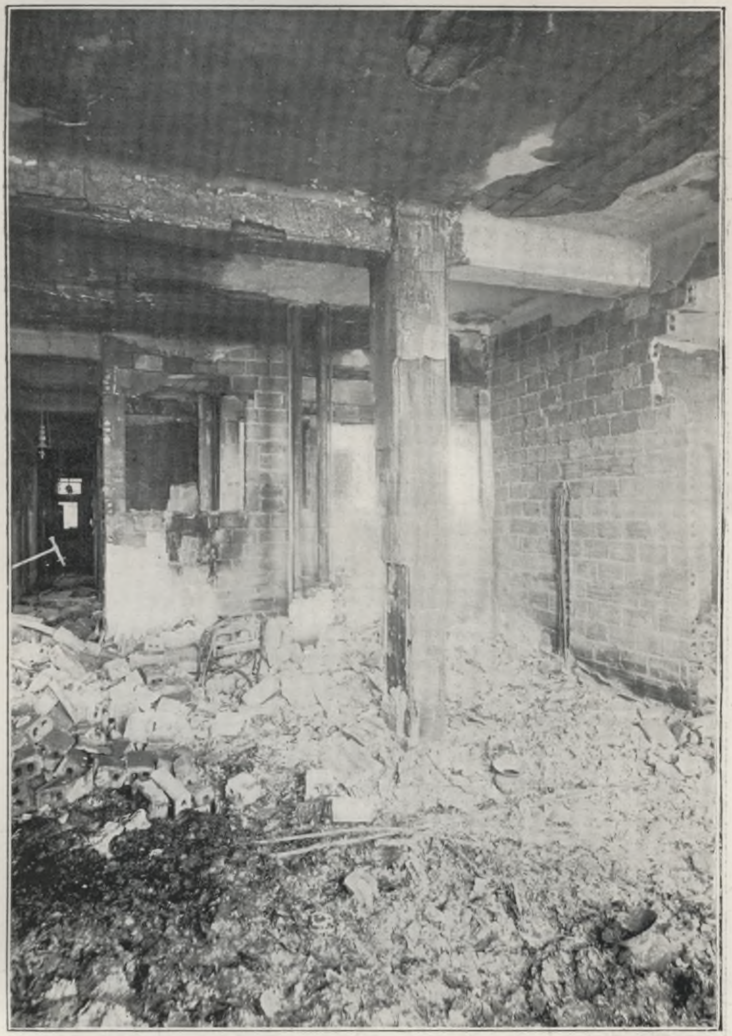

FIG. 8. 13TH FLOOR. THE COLUMN AND GIRDER ARE UNINJURED.

uninjured, although there is nothing left of the wood flooring in the rooms adjacent. The amount of wood used was no doubt excessive, viewed from the standpoint of best practice. The photographs show that wood-work will not stand a hot fire, even when embedded in the walls. Other material can be adopted for chair-rails, bases, and panellings without injuring the appearance or the utility of a building.

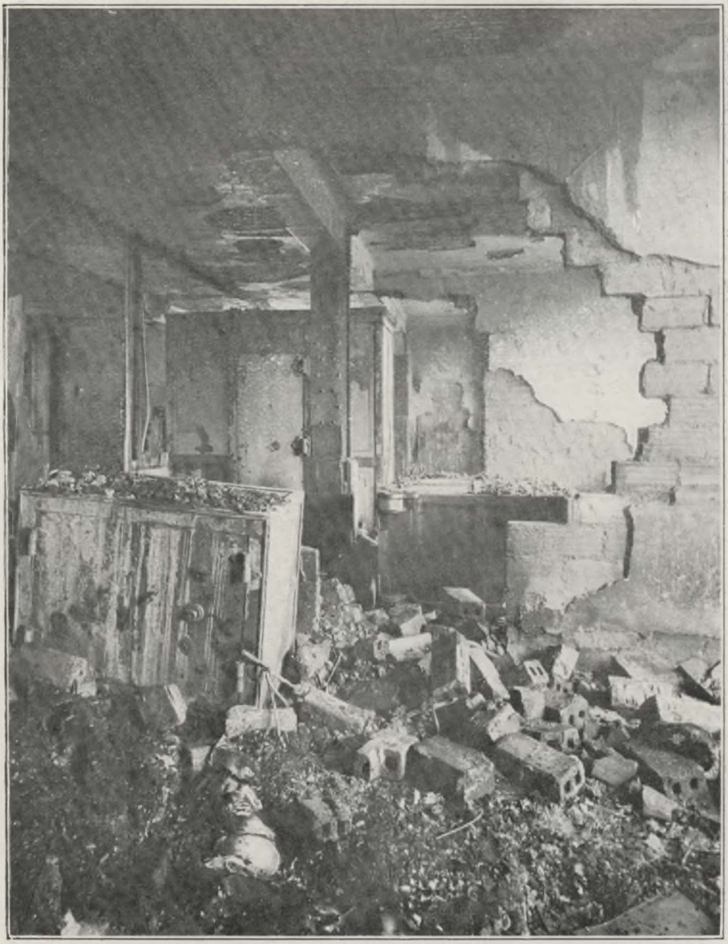

FIG. 9. 14TH FLOOR, FRONT. SHOWS GENERAL DESTRUCTION OF CONTENTS.

Fig. 7 shows a partition in bad condition in a room on the twelfth floor. Some of these partitions were built directly on the flooring, and their failure was caused principally by the burning of the wood, depriving them of their natural support.

Fig. 8 is a view on the thirteenth floor, showing a column with a portion of the fire-proof blocks removed

FIG. 10. 16TH FLOOR. A DISTORTED GIRDER IN THE FRONT OF THE BUILDING.

in order to make an examination of its condition. As is clearly seen in the photograph, the column was uninjured and still covered with paint, although the heat in the room was sufficient to destroy the expanded metal and plaster covering the pipes placed against the rear column. The ceiling in this room and the partition of terra-cotta remain intact, although all the wood-work was totally consumed.

Another column is shown in Fig. 9, which is a photograph of a room in the front of the building on the fourteenth floor. The covering had been removed from this column for the purpose of examination. This picture shows the plaster-work completely destroyed, although the partitions and ceiling blocks remain intact. The floor arches also remain unbroken, although the safe shown in the picture fell over on its face, on account of the destruction of the wooden flooring upon which it rested. The partition shown in this picture was torn away by the firemen, in order to facilitate their work.

Fig. 10 is a photograph taken on the sixteenth floor in a front room of the building. The column remained uninjured, as is shown by the subsequent removal of the terra-cotta blocks. The partitions of terra-cotta on this floor remain intact, although the plastering was completely destroyed. The distorted girder probably represents the greatest damage done to any one member of the metallic frame. This was one of the main girders of the building, and was protected on the soffit by terra-cotta blocks and wire lath. It differed, however, from the other girders in having its upper chord project above the floor. The part projecting was not protected by fire-proofing material, but was boxed in with wood, forming an elevation in the floor-space of these rooms. This wood-work, of course, was completely destroyed, leaving the metal exposed to the fire. No doubt this portion of the girder became heated, and buckled on account of being in compression. Had the exposed part been in tension, it doubtless would have retained its shape, as there is no evidence to show that the heat was sufficient to have injured it under such conditions.

The fire had no difficulty in entering the building, as all the windows on the north side were unprotected. The building might have been saved, had these windows been equipped with iron shutters, and had wired glass been used in a metallic frame. This wired glass will resist an immense amount of heat, and, although it breaks in time, the pieces remain in place. Metal frames fitted with wired glass could have been used to advantage in all the partition transoms. Such an arrangement would have given nearly as much light throughout the building, and would have been a better fire stop.

The flames, on entering the elevator shaft, appear to have gone at once to the sixteenth floor, as the destruction of the trellis work and iron framing around the elevator doors is greatest at that point. Owing to its position, the staircase was rendered useless as soon as the fire obtained considerable headway, although, as constructed, it was partially protected by the division wall between it and the elevator shaft. The stairs remained intact, so that they could be used as soon as the fire was extinguished.

The front of the building was built of solid marble, the poorer pieces obtained from the quarry being used as backing. The façade was relieved with balconies and other ornamentations, and a row of columns supporting arches made a finish to the fifteenth and sixteenth floors. The fire totally wrecked the marble, wherever it was exposed.

Marble and granite have but little fire-resisting power, and it seems useless to adopt them in a building intended to be fire-proof. They are so susceptible to heat as to be liable to injury by fires occurring at a considerable distance. A greater heat than that to which the marble was exposed was endured by the brick-work on the north face, and by the brick-work up the light well. The chief visible damage to this was the cracks caused by the expansion and contraction of the braces reaching across the light well and stiffening the two wings.

Taken as a whole, the building resisted the action of fire remarkably well. Within a week many of the offices on the lower floors were again in use. The steel structure, with the exception of a few portions, such as the girder mentioned above, can remain without repairs. The damage to the floors was slight; and, although the total wreck was great, it was practically limited to the trim and contents of the various rooms on the upper nine floors. The front wall, however, was ruined from the eighth story up. No doubt the destruction would have been less, had as much care and energy been bestowed upon the details of construction and finish as were given to the main frame-work and general plan.

The building contained its own fire apparatus, but it is reported that this failed early in the evening. Owing to the height of the building, it was impossible for the fire department to reach the seat of the conflagration. The fire, therefore, had great liberty, although it was effectually prevented from spreading to the lower floors.

Here was a building which was, in the ordinary sense, a fire-proof structure, and yet it was damaged. Again arises the question: "What constitutes a fire-proof building?" It is evident that, if fire is brought into contact with articles that are combustible, those articles will be burned; and that, if the fire must be confined to one specific space, that space must be enclosed effectually by absolutely fire-resisting material, which must be so constructed as to form practically a furnace. Such construction is not applicable to a building used for ordinary purposes. The next step, then, is to so arrange the structure that, when fire takes place, no damage shall be done to the main members, whether those members be of masonry, iron, or steel.

In all our cage constructions the members needing the greatest protection are the columns, girders, and beams. It is not difficult to protect these members effectually, provided the owner and the designer are willing not only to spend the proper amount of money and care, but to give up the requisite floor-space. This part of the problem was fully illustrated in the Home Life Building, as the only members seriously injured were the unprotected parts of the metal structure. It is axiomatic to state that floors should be separated from each other, so as to confine the flames. This is a condition difficult to attain, as perforations must be made for both stairs and elevators. These openings are generally placed so as to take a minimum of floor-space, and thus render a maximum area available for income-earning purposes. Nearly every intending builder examines the various buildings, estimates the amount of space devoted to public use, and concludes that the best building is the one that has given up the least percentage of space. While this effort is commendable from the purely income-earning standpoint, it not only has the effect of rendering the design dangerous to life and property, but makes it almost an impossibility to so design a building that it shall be fire-proof.

In any building there must be, and always will be, an amount of combustible matter that cannot well be reduced. It is, therefore, essential that the least amount of combustible material shall be used in construction. In those rooms in the Home Life Building which suffered the least damage, it was clearly shown that the combustible materials placed near the ceiling were destroyed more rapidly and more completely than those nearer the floor. The heat and flames naturally follow the ceiling, and the ordinary fire-proof partitions in which there are large transom windows are thus rendered useless as fire stops. The use of transoms in these partitions is no doubt a necessity, but they should not be fitted with material so friable as ordinary glass.

Even in a fire-proof building dependence must be had upon human aid. When the building is tall, it towers beyond the reach of the fire department, and reliance must be placed upon other means. A fire in the lower stories is easily accessible; the conditions to be most dreaded are those of a fire in the upper stories.

FIG. 11. SUGGESTIVE OF THE DIFFICULTY OF REACHING THE UPPER STORIES OF A SKY SCRAPER WITH A FIRE STREAM.

The difficulty can be inferred from Fig. 10, which is a view of Broadway, N.Y., from one of the upper floors of the American Surety building. Many modern tall buildings are designed with their own pumping plant to supply a roof tank for fire and other purposes, and are equipped with a large stand pipe from six to eight inches in diameter, which is siamesed on every floor for hose connections. This stand pipe is also arranged with a check valve and with siamesed branches at the foot, so that fire engines can be attached, in case of the disability of the self-contained plant. It is well so to arrange the stand pipe that the engines can also operate in conjunction with pumps in the building.

In many cities which maintain a system of fire boats there are laid underground pipe lines of large diameter. As these fire boats are equipped with pumping apparatus far exceeding the power of the largest land engines, they are able to force water under heavy pressures to long distances, provided the mains are made of sufficient area to minimize the friction losses. This system, operated in connection with the building stand pipe, would materially assist the firemen.

The question naturally arises whether it pays the the owner to make a building thoroughly fire-proof. Unfortunately there are many who build for the specific object of obtaing the greatest income from a minimum outlay, and the effort to save on the first cost is so great as to render their judgment valueless as to what should or should not be done. Tall buildings of cheap construction are a menace not only to the owner and tenants, but to the community. Too much stress cannot be laid upon the great aid that could be rendered, but unfortunately is not, by the insurance companies. If they would be more strict in the classification of their risks, improvement would immediately follow.

Are these tall buildings really good investments? The increase in height appreciates the value of the land, but how much of this appreciation is offset by the depreciation of the building, by the extra cost of maintenance, insurance, repairs, taxes, interest, etc.? In other words, would not a smaller building pay a greater percentage upon the money invested, if a careful and accurate balance-sheet should be drawn up? Following the same line of thought, there has arisen the question whether the height of buildings should not be limited by law? If every building could be constructed upon utopian principles, probably there would be no reason to limit the height other than one of a purely æsthetic character. As such a state of affairs does not, and probably never will, exist, and as so-called fire-proof buildings are liable to be constructed, it seems that some form of proper restriction would be advantageous to the community.