FIREPROOF CONSTRUCTION

AN AUTHORITATIVE PRESENTATION OF THE FIRE PREVENTION PROBLEM, GIVING THE HISTORICAL DEVELOPMENT OF THE ART OF SAFE BUILDING, AND THE BEST MODERN PRACTICE IN FIREPROOF AND FIRE-RESISTING CONSTRUCTION

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CONTENTS

PART I

FIRE AND FIRE LOSSES

PAGE

Conflagrations 2
Evolution of combustible dwellings 5
Great fires of history 9
Baltimore fire 10
Route of flames 12
Evidences of intense heat 15
Analysis of the damage in tall buildings 16
Fireproof lessons from Baltimore fire 21
San Francisco fire 26
Building conditions before the fire 27
Story of spread of conflagration 34
Failure of water supply 34
Effects of dynamite 37
Complications of earthquake and fire 45
Slipshod methods in rebuilding city 48

Fire's havoc 51
Waste of property 52
One year's fire losses 55
American vs. foreign fire losses 58
Analysis of losses in United States 59
Losses in treeless States 63
Losses in timber States 63
Remedy for depletion of timber and iron supply 67
Fireproof construction only protection 71

Causes of fire 75
Primary and secondary causes 75
New hazards 77
National building code 78

Fire extinction 80
Use of water 80
Use of chemicals 80
Use of live steam 81
Automatic sprinklers 81

PAGE

Insurance idea 82
Insurance policy no protection 83
Insurance statistics 92
Neighboring risk in Europe 93

PART II

FIREPROOF CONSTRUCTION

Stimulus to good building 1
Legislative control 2
Remission of taxes 4
Labeling buildings 5
Neighboring liability 6
Public opinion 6

Building conditions in American cities 12
Proportion of poor buildings 12
"Skimped" buildings 13
Conditions compared with Europe 14

Real fireproofing and its value 15
Importance of good design 16
Fireproofing as an investment 16
Insurance vs. fireproof construction 20
Economy of fireproofing 27
Ignorance retards growth of fireproofing idea 29
Popular misconceptions of fireproofing 33
Contents and finish of buildings 36
Isolated units in buildings 36
Steel and tile or concrete frame 41
Wire glass and other protective features 43

"City unburnable" a possibility 44
Municipal regulations 45
Attitude of architects 51

Evolution of building construction 55
Early forms 55
Stone and brick 57
Unprotected iron and steel 57
Tile protection 60
Corrugated and plate floor construction 63

Evolution of building construction PAGE
Mill construction. 64
Steel frame buildings. 69
Reinforced concrete. 72
Uses of cement. 74
Dangers and limitations of concrete. 78
Steel and tile vs. reinforced concrete. 80

Fireproof building in detail. 97
Outside walls. 97
Ornamental surfaces. 97
Wall openings. 99
Doors and window shutters. 99
Wire glass windows. 100
Skylights and transoms. 102
Roofing. 103
Piers and foundations. 104
Structural parts. 105
External light courts. 106
Stairs and elevator shafts. 107
Halls and exits. 107
General fireproof features. 109
Wall finish. 109
Furnishings. 111
Special requirements. 111
Theaters. 111
Assembly halls. 113
Churches. 113
Hotels. 113
Fireproof homes. 115
General characteristics. 116
Several plans in detail. 121
Standard tests of building materials. 136
Methods of retarding fires. 145

Concrete from the fire-resisting standpoint. 151
As building material. 151
Construction development due to concrete. 153
Early forms. 153
Applications of concrete. 154
Girder and slab types. 154
Mushroom type. 159

Concrete from the fire-resisting standpoint PAGE
Fire resisting qualities. 159
Fire records and tests. 166
Peavey Elevator Company. 166
Huyler Candy Factory. 166
Dayton Motor Car Works. 169
Thompson & Norris Building. 175
F. W. Tunnell & Company Building. 175
Concrete cottage at Winthrop Beach. 179
F. B. Klock Building. 183
Rubber Reclaiming Plant. 184
McCray, Morrison & Company Elevator. 186
N. F. P. A. Report. 187
Laboratory tests. 193

INTRODUCTION

FIRE was for centuries looked upon as an inevitable accompaniment to civilization, a sort of necessary evil, but only to be reckoned with *after* it had gotten started. Vast sums of money were expended in fire-department equipment, and the members of those departments were expert indeed in casting literally oceans of water upon the flames, often doing more damage by water than was done by the fire. This was called "Fire Protection". But fire losses in life and property went merrily along, increasing at an appallingly greater ratio than did our population or wealth, until it was finally recognized that they constituted an absolutely unbearable tax upon the communities, though the individual received some imaginary solace by being indemnified for his property-loss by Insurance.

¶ The Press, the greatest reform power on earth, did splendid work in awakening the Nation to its terribly fire-ridden condition, and when once well started Fire Prevention went along with a vim. The result is that a large majority of the cities and towns in the Union have revised their Building Codes during the past few years; Fire Prevention societies have been organized; fire departments have given attention to intelligent prevention as well as to extinction; individuals have become more careful (subconsciously, probably) in avoiding connecting matches and lighted cigarettes with waste-paper baskets; manufacturers, realizing that in safety was the best profit, have built and installed automatic sprinkling devices. In fact, a veritable wave of prevention is now sweeping over the entire country.

¶ In spite of this progress, there is yet much to do. Our fathers' disregard for safety, their blind confidence in Providence or good luck, and our own early indiscretions in the same line, have provided so very much fuel for fire that, build as well as we may, our old fire traps assure us of years of worry and loss. Now that we as a people have been awakened, we must keep on intelligently working at the problem of bettering our building conditions in order to prevent our lapsing into the old methods which have proved so dangerous to life and property. The American School of Correspondence, realizing the demand for expert knowledge of the subject and the necessity of stimulating this "awakening" of the people, prepared recently a most comprehensive course of instruction in the fields of fire prevention and insurance. With the idea that there are thousands interested in the subject of prevention—the answer to which is fireproof building—the publishers offer this section of their complete work as a readable presentation of the building situation of today and of the methods and practice which have been found safe and reliable. It presents something a layman can understand and appreciate, something the business and professional men, who have neither the time nor inclination to take up the matter in its complete form, can digest and apply to their own building problems. The book is published in the hope that it will help to spread the gospel of "good building" throughout the country, and decrease our national fire losses to the sane basis which has been maintained in Europe for many years.

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FIRE AND FIRE LOSSES

INTRODUCTION

From the beginning of time fire has played a most important part in the world's evolution, changes, progress, its very existence. Physicists will tell you the composition of fire, its why and wherefore, but with all that we are not now concerned. Suffice it for us that fire is what might be called, for our purpose, *the visible expression of heat.* Without solar heat there would be no life here; absolutely everything depends upon it. But we are not dealing with "reflected solar rays" and such highly interesting but ultra-scientific matter; we have in mind now mere *fire,* the combustion of inflammable materials by ignition and the destruction or damage to many materials by exposure to great heat generated by fire—plain, terrestrial burning.

This fire that we know about, that we see, that we fear, and that we use, is sufficiently important to engage all of our attention. It has made and unmade continents; it has been turned into power, steam; with it nine-tenths of our food is prepared; properly subjugated it is our most important ally, whilst unharnessed and running amuck it can destroy and has destroyed in an hour what nature has taken centuries to make, and what man has spent years in fashioning. It is the most dreaded of devastators; it has been used in war not only as a means of discharging murderous weapons, but in its crude state, so to speak, as an auxiliary which ranks with carnage and rapine. In the form of conflagrations, it has supplied some of the most spectacular and memorable and saddest events in history. The ancients soon recognized its potentiality and gave fire an equal place in their worship with the sun. Fire-worship is found among

The author begs to acknowledge his indebtedness to the Insurance Engineering Magazine, the Metropolitan Magazine, Popular Science Monthly, Cement Age, the Roebling Construction Company, the National Fireproofing Company, the U. S. Geological Survey, and the Building Departments of many cities for data, reports, the use of illustrations, and many other courtesies.

the oldest of peoples; in Babylon it ranked almost equal with the worship of their great god, Baal, the sun god, and next of kin to the Jupiter of the Greeks and Romans; in Peru and ancient Mexico it had its place in the theogony of the times. It was practiced by our own North American Indians, and, in fact, has always ranked quite equal if not superior to the astral worship of nearly all polytheistic peoples. All nations and peoples and races turn fire to the practical usages of heat-producing and cookery, and some have even gone so far as to cultivate a taste for eating it. This latter feat, however, has been and is generally performed only by fakirs and jugglers. But we have some well authenticated cases on record that show it was no trick but an actual accomplishment, molten wax and pitch being swallowed while aflame and that in the presence of learned professors and investigators not likely to be fooled by, or to lend themselves to, any mere trick.

Enough for the subject of fire in general. Its ramifications are most interesting, the development of its use for cooking raw foods, the different manners or modes of producing heat or power with it, —how in the latter connection, it may well be said to "turn the world"—any one of these details is fascinatingly attractive and would tempt us to linger with and study it. But now fire is to be discussed only in its destructive aspect—the great conflagrations of our own times, the havoc they and the "ordinary" fires make with life and the work of men, buildings, and contents; the causes of these fires; the means taken to stop, cure, or prevent them; and, lastly, the most important of preventive measures—*the fire-resisting construction of buildings.*

CONFLAGRATIONS

Man is a gregarious animal and from the earliest times has sought to live in communities. Defence against other tribes or wild animals was thus made easier and life generally more bearable. As soon as he emerged from the caves and burrows of remotest antiquity and began fashioning habitations of his own handiwork —even the rudest tents of animal skins stretched upon poles—he laid the foundations, so to speak, for the conflagrations and terrible devastations by fire of later times, for the structural portions of those tents were inflammable, and their coverings, unlike the huge boulders

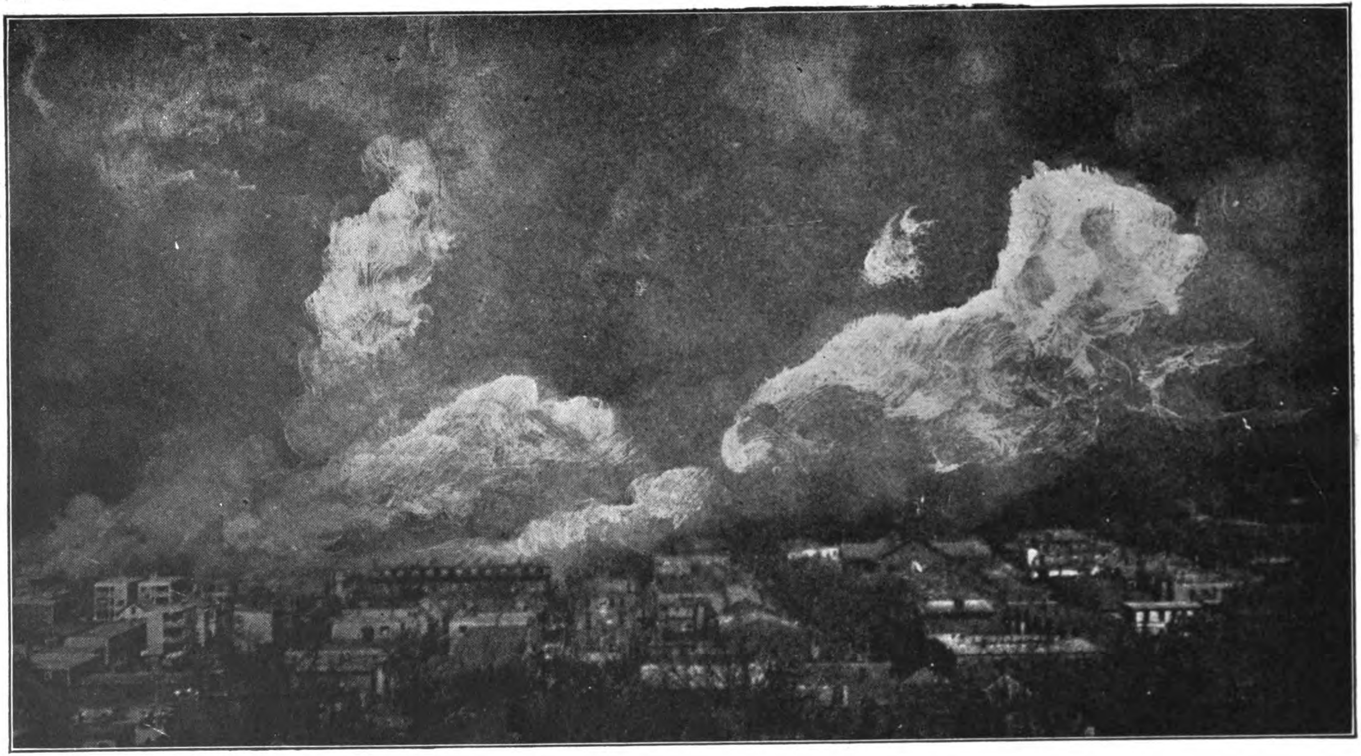


Fig. 1. View of the Great Chelsea Fire (Boston)

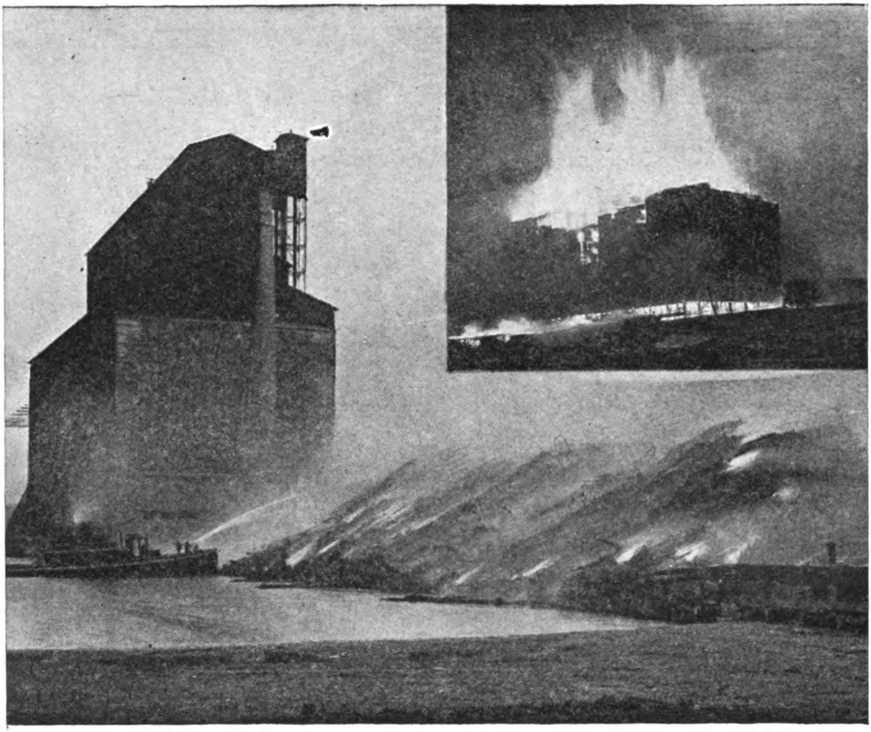


Fig. 2. A Spectacular Fire in a Grain Elevator

There have been 2,385 such elevators destroyed in seventeen years in this country alone. The lack of fireproof elevators in Chicago is largely to blame for that city's loss of its title of "the greatest wheat market in the world."

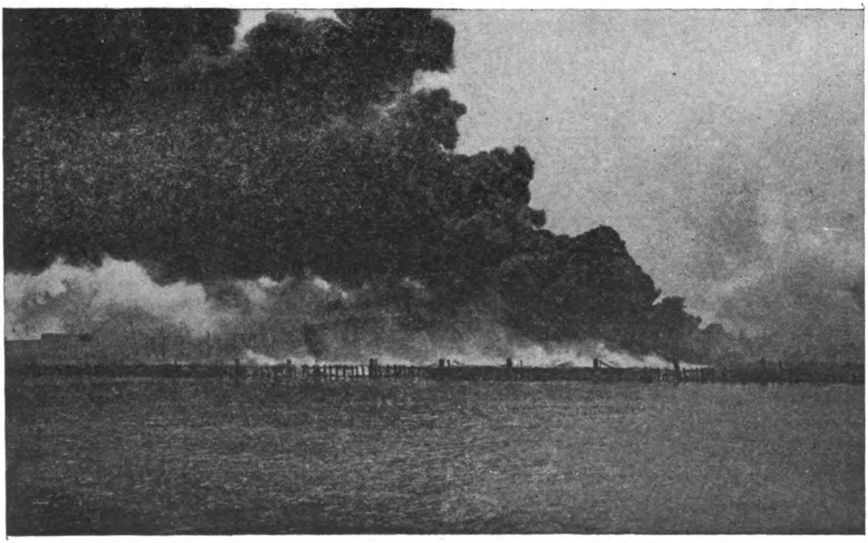


Fig. 3. The Huge Pall of Smoke that Hung Over San Francisco During the Fire

and rocky walls of his first home, were damageable, destructible by fire. Combine those qualities with carelessness and ignorance and you have all the essentials for a conflagration, ancient or modern.

Peoples living in the vicinity of laminated rock formations had already quarried and used it in what might be called *crude masonry* to build their homes. In the course of time, however, they learned to quarry stone in the shapes and in the quantities they desired. Others, living upon the plains, away from the forest and where stone, and even field rocks were few, devised a mode of forming clay into rough blocks that could be handled in building walls to enclose their "houses," or worked up these walls solidly of "adobe" clay. mud that soon dried and offered a very adequate protection, only one surface ever being exposed thereafter to the weather. From this early beginning sprang the later art of brick-making, first merely sun-dried or baked brick, and later kiln brick, the most perfect and only imperishable material of any time, ancient or modern. To it we owe most of what we know about antiquity. Documents and records written upon papyrus, or leather, or any other fabric, have been burned, obliterated, passed away, those graven upon stone and marble or fashioned in metal have been severely dealt with by time and the elements, so much so as to be of little or no value to the historian; but those wrought in burned clay, and even the dates inscribed upon the bricks of the temples, the urns, the tablets, are as fresh and legible today as when they left the kiln two, three, seven thousand or more years ago.

By far the greater number of peoples have lived where timber was easily procurable—and therefore wood has become the most common medium for the builder to work in and has stayed such through all ages. The demands made upon the forests of the earth have been insatiable, and as careless methods of lumbering have always been in vogue, actual denudation has been the order of the day. Only the most intelligent and careful people have ever made any attempt at reforestation; the amount actually done is so small as to be absolutely negligible. So today, the world over, there is an actual scarcity of lumber, prices have mounted sky-high and, perhaps luckily, we at last have to resort to other materials in the construction of buildings.

Only as much foresight as it required to prompt the farmer to prepare his ground and plant another crop after he has reaped one harvest would have been necessary to secure for us and all posterity an abundance of timber. The ruthless deforestation practiced, particularly in America, has not only produced a scarcity of lumber but it has also entirely changed the *complexion,* so to speak, of vast sections. Exposing the earth's surface to the free action of rains and snows and sun has permitted erosion to such an extent that valleys have been filled up, arable hills have been worn down to bare rocks, the course of streams has been altered, waste places

Fig. 4. The Folly of Planing Mills and Wood Yards within the City Limits
This was the beginning of a $2,000,000 fire.

have been made where thousands of men could have cultivated and lived profitably, life-giving rain precipitation has been checked, and the very climate has been tampered with.

Naturally, wood being one of the most combustible of materials, and whole cities being built of it, destruction by fire has ever been most common. Even in the countries where stone and brick were used in construction, the roofs of buildings, the fittings, and the furniture were in great part wood, sufficient always to supply ample material for combustion, so that everywhere and at every time great fires have been the order of the day. Tyre, Babylon, Alexandria,

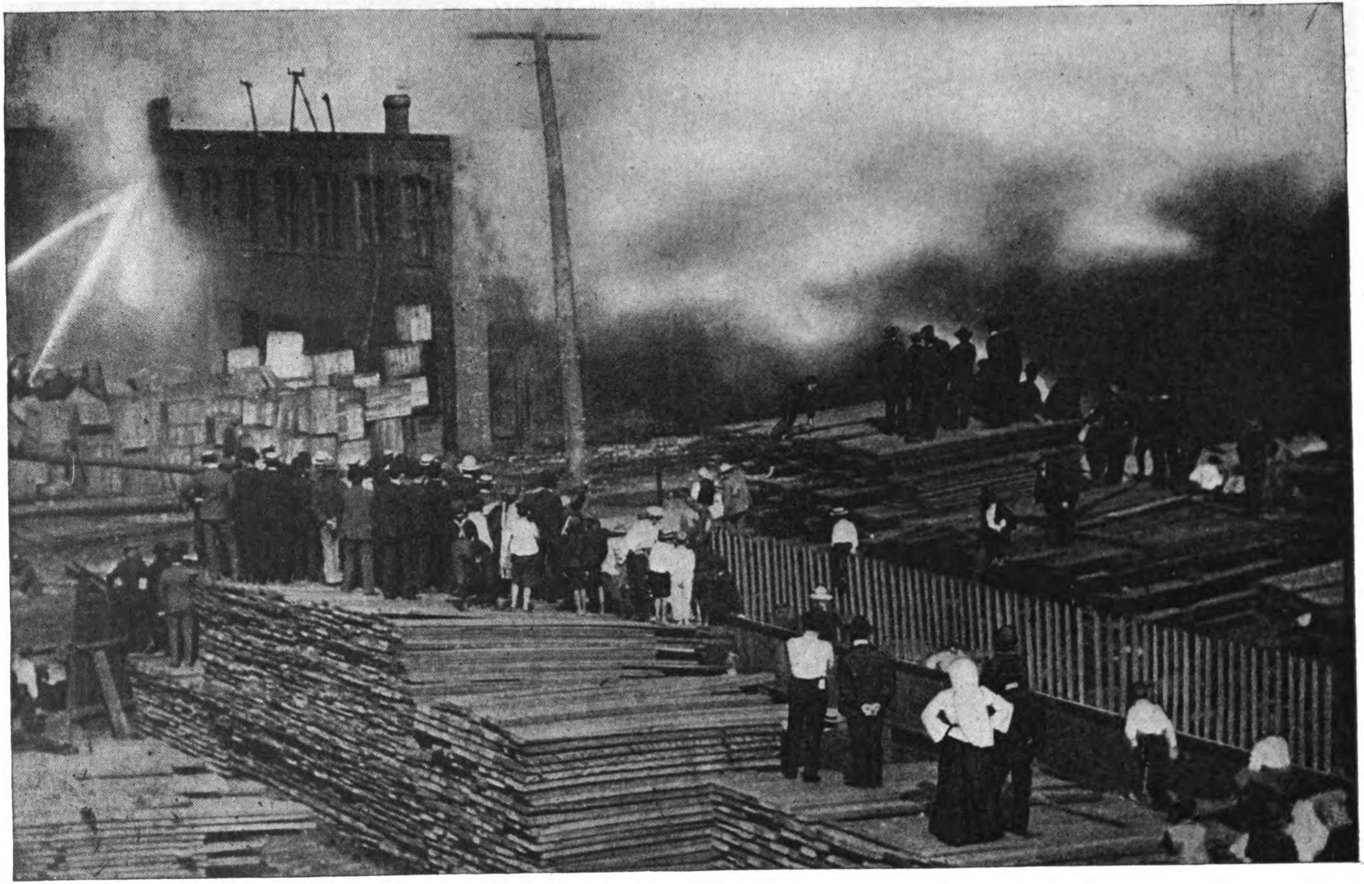


Fig. 5. The Curse of Our Cities—Wood, Wood Piles, Lumber Yards, and Wooden Buildings

Thebes, Rome—every city of old was the scene, sometime or other, of a great conflagration, a holocaust; and lucky, indeed, was the city that was so visited or entirely destroyed but once. In more modern times fire has wreaked even greater havoc. The "London Fire," the "Burning of Moscow," and such events are epochs in history.

In what may be termed *our own times*, there have been conflagrations that made those old epoch-making blazes fade into utter insignificance. We supinely accept them as necessary evils and no longer consider "extraordinary" anything that recurs every two years or so—there was but that time between the fires of Baltimore and San Francisco, and we are just about due another great blaze and have done very little to head-off that ever impending evil.

We Americans are prone to gauge most things by the dollar mark. And perhaps it is, though so unsentimental, as good a standard as any. Let us accept it here as an indication of the extent of some destruction done by conflagrations in comparatively recent times. Table I gives the time and place of these great single fires and the approximate damage wrought to property. In most of them, too, great numbers of lives were lost, but with that most distressing feature we are not at present concerned. Mark, too, that these are all fires of $10,000,000 and over. The number of serious ones, really conflagrations but of *only* a few million dollars, is simply legion.

The seriousness of our "ordinary" or "small" fires can be appreciated by scanning our fire report for June, 1910, a very normal month, during which no really "big" fire took place. Yet there was an average of one conflagration a day, burning up at least one whole block, of six to nine buildings; in ten cases the fire consisted of more than twenty distinct separate buildings, and in seven of those ten cases it was a "general" fire where a goodly part or all of a small town was totally wiped out of existence.

During the past twenty-five years I have either witnessed every great conflagration there has been in this country or been upon the ground as soon afterward as steam could carry me. The effects of fire upon buildings, the spread of fire, its action, the effectiveness or the ineffectiveness of water upon it—all phases of the subject are then at their best, if we may so express it, to be studied; one can see so well what theories are exploded or confirmed, where a weakness in defense was fatal, that he can plan new lines of attack

TABLE I

Great Fires of the Past 80 Years

Dec. 10, 1825	New York City	$ 17,500,000
May 4, 1842	Harrisburg, Pa.	35,000,000
Aug. 6, 1848	Constantinople	15,000,000
May 4, 1851	St. Louis	15,000,000
Dec. 12, 1861	Charleston, S. C.	10,000,000
July 5, 1866	Portland, Me.	10,000,000
June 5, 1870	Constantinople	25,000,000
Oct. 8, 1871	Chicago	165,000,000
Nov. 9, 1872	Boston	70,000,000
Sept. 3, 1876	St. Hyacinthe, Can.	15,000,000
June 4, 1877	St. John, N. B.	15,000,000
Dec 11, 1882	Kingston, Jamaica	10,000,000
July 8, 1892	St. Johns, N. F.	25,000,000
Oct. 5, 1896	Guayaquil, Ecuador	22,000,000
Apr. 27, 1900	Ottawa, Canada	10,000,000
May 3, 1901	Jacksonville, Fla.	10,000,000
Feb. 7, 1904	Baltimore	60,000,000
Apr. 10, 1904	Toronto, Canada	12,000,000
Apr. 18, 1906	San Francisco	350,000,000

upon the dread devastator. Such a study of fires is fascinating and has led to some beneficent results; municipal building departments, insurance companies, the business world generally—all are now giving this subject intelligent attention with the idea of minimizing the fire-havoc that until comparatively recently it has been the custom of believing inevitable.

The fires of many years ago furnish us lessons of indifferent value; but the Baltimore and San Francisco fires are of such recent occurrence and are so valuable, from the fire-expert's point of view, in that they were the only ones in which the new "sky-scraper" buildings had ever been involved and our theories of "fire-proofing" had ever been given conflagration-tests, that we may well afford to go somewhat into detail and give them more than a casual glance.

The following two excerpts are from reports made by me after exhaustive study of both fires and many weeks of delving into the ruins. These investigations were made at the instance of and for the U. S. and other Governments, Municipal Societies, Building Departments and such bodies. Some of the data and photographs obtained are absolutely unique, for, armed with the proper authority, I managed to examine and photograph many buildings and dangerous ruins while the wreckers protestingly waited to dynamite or pull them down.

THE BALTIMORE FIRE

Never before have our theories of fireproof construction received so severe a test, and that those skyscrapers are still standing and that their structural members that were properly protected are intact, is all the vindication the most enthusiastic of the supporters of modern fireproofing theories could hope for.

Something like one hundred and fifty acres of territory were gutted. In Fig. 6 is shown the trend of the main blasts, as it were, of the fire. It originated at the point marked by the white cross, and spread with greatest velocity in the direction of the first arrow. There was a high wind blowing, some say almost a gale, of forty miles an hour. The fire jumped to point 2, and swung along in the contrary direction to the first trend, sweeping in a curve and diverging into two forks, as indicated by the arrows. When the fire reached the diverging point, sparks or some other cause created an outburst at point 3, and the fire worked along in a northerly direction with lightning speed on the line shown by arrow 3. The northerly point of arrow 2 seemed to be about the hottest of the fire. Spectators say that it seemed to linger there and put forth its mightiest effort to utterly consume everything within its grasp. The trend of the fire there seemed, to be a sort of vortex rather than a tendency to spread, but soon it started off again on the line marked by arrow 4, in an almost due southeasterly direction, an irresistible, unyielding force, against which it was useless to battle. A considerable time after fires along line 4 were burning fiercely, another trend was started at point 5, and continued in nearly a parallel direction to the other. The fire apparently burned fiercest on those lines indicated on the chart; however, it spread all about, beyond and between those lines, but in a more leisurely manner. The portion shaded darkly on the map shows the section that was fire-swept and the black line outside of that district shows the police and militia patrol limits within which no one is allowed without a pass from the authorities.

I was able to verify the accuracy of these lines on the chart by noting the intensity of the heat as indicated by its action on the

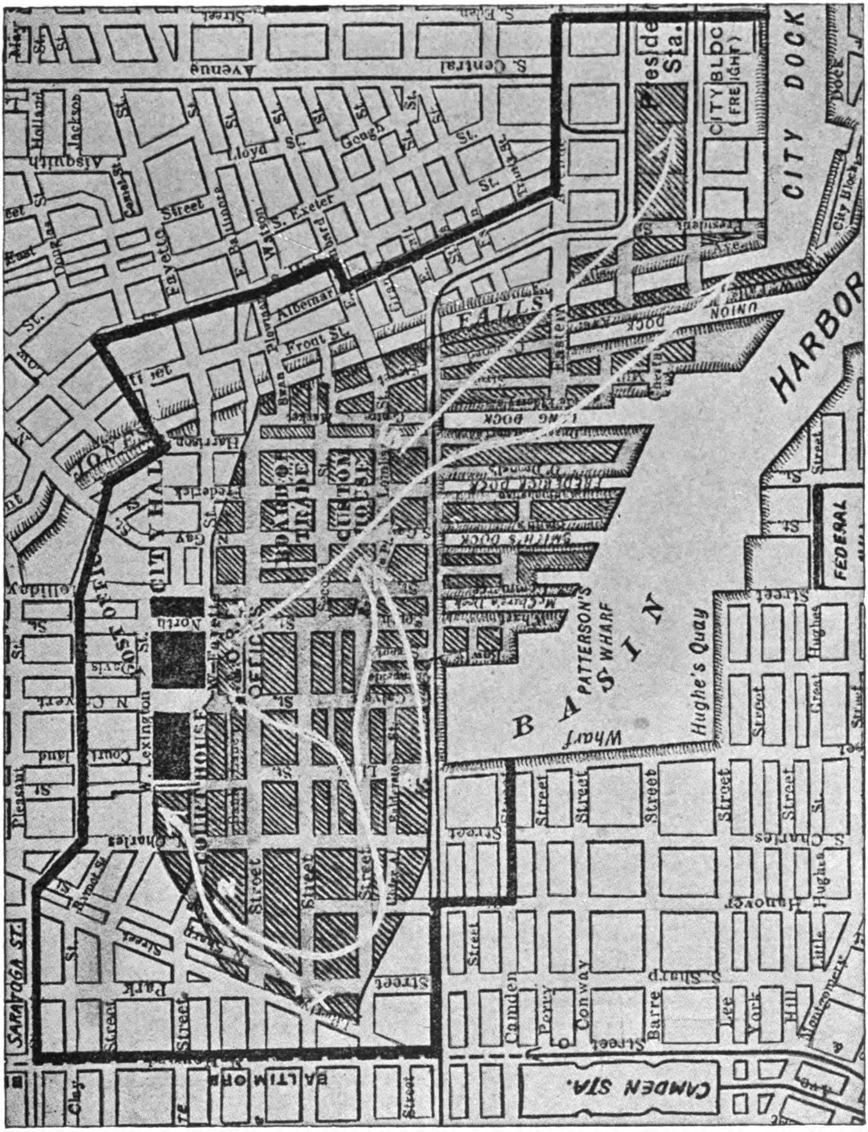
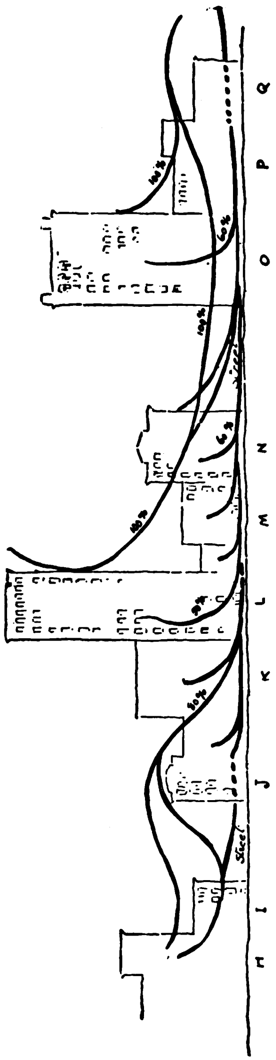


Fig. 6. The Baltimore Fire

The shaded portions show extent of fire zone, the dark line of the military jurisdiction after the fire, and the arrows the direction of the fire currents from starting point X.

metals and brick and stone, and while the wind evidently played some peculiar pranks and made strange twistings, the terrible drafts created by the fire itself performed some wonderfully acrobatic feats,



FLAME ROUTE OF THE BALTIMORE FIRE

Showing how the tall steel and tile fireproof buildings received the severest test and stood impregnable. The structural members of all these buildings were uninjured.

This diagram shows the vertical convolutions of most intense heat. It is typical of the varying conditions in one comparatively direct line. The fire swept crosswise and all about, but, as judged from the effects of the fire on metal and combustible material, a line of intense heat swept over Q and attacked P and O, as indicated by the 100 per cent line, with another attack at O, higher up, as also indicated by the 100 per cent line. Then that line of fiercest heat seemed to continue on and strike the other tall building, L, about as indicated; meanwhile a fire, by comparison with the first would equal about 50 or 60 per cent of it, swept along nearer the ground, eating up into each building, until everything combustible was entirely destroyed, but either sweeping around Q and J or over those two buildings, that remain virtually untouched by the fire. H and I show the effects of the fiercest attack, at points indicated by the wave lines. The fact of certain buildings, lampposts, signs, etc., being left untouched while everything about them is destroyed, clearly indicates that counter currents of air were encountered, or almost vacuums formed by the fire itself.

Fig. 7. Flame Route of the Baltimore Fire

so to speak, in twisting the lines of action vertically as well as horizontally. In places it would seem as if the blast had passed over three- and four-storied buildings to attack the six- and seven-storied ones most fiercely, while leaving the former to burn more slowly, and sometimes from the top down. Three or four buildings escaped in this manner from absolute destruction; one, the Safe Deposit Company building, a two-story, well-built affair, went *scot free,*

Fig. 8. The Hurst Building where the Baltimore Fire Started

the brickwork and the iron shutters showing really but very little of the effects of the terrific heat that must have been all about it.

Some actions of that fire baffle scientific explanation. In the very case of this Deposit Company building, I can understand how the fire could have swept over it so quickly, and, there being nothing about its exterior that would readily ignite, that it should escape; but some distance away and across the street from the new Custom House stands the old United States stores building; on every side of this building its neighbors have been completely gutted, while it stands to all appearances absolutely intact. The glass in the windows is not broken and the window frames are but blistered, while the shutters inside the closed windows are charred and

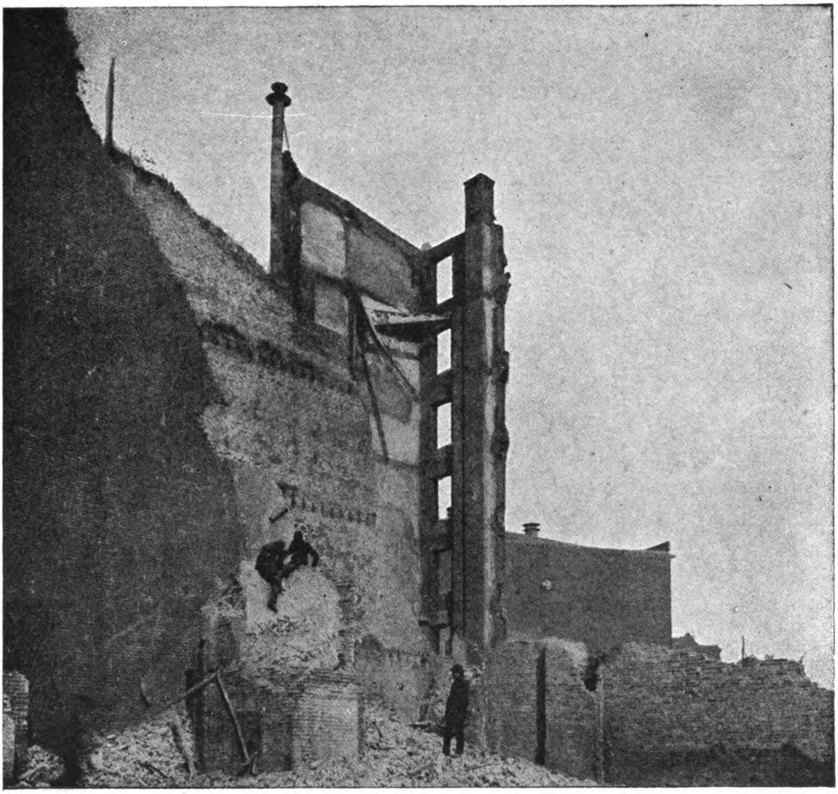


Fig. 9. A One-Time Popular Hotel in Baltimore

scorched. Could the heat simply have been intense enough to scorch this woodwork inside, through the plate glass, but, unaccompanied by flame, and being influenced by counter currents of air, leave the extèrior unmarred? The building suffered some in the upper story by reason of the breaking of the skylights and the fire getting in that way. Other pranks of the fires are shown here and there in the streets; a wooden telephone or telegraph pole stands comparatively untouched, while nearby an iron one is twisted into all sorts of shapes.

The combustion in the buildings was complete and most searching. Usually after a fire there will be charred bits of floor joists still sticking to the walls and masses of closely-packed goods or papers on the ground, their very density preventing their combustion. But not so here. In most of the buildings burnt, particularly along the lines of the most intense fire shown in the diagram, there is not a vestige of anything but stone, brick, and iron left. One would think that the draft had drawn up whatever little residue there might have been and scattered it about in cinders and dust. Charred papers were found miles off, and whole sheets of tin were carried blocks away. Indeed, the suction or draft created was so great that many skylights and iron roofs appeared to have been lifted before collapsing. Some of the skylight glass appears to have been broken outward, too, and before fire could have had effect upon it from within. In some buildings the glass from the windows is mainly within them, and in others it is on the outside and well away from them, again showing that the suction of air along those streets, toward the vortex of the fire, must have been something tremendous. Furthermore, in some buildings there is very little glass to be found—it seemed to have disappeared; while about others were found stalactite formations of fused glass, which indicated the terrific heat that must have been generated.

On the sidewalk in front of one building, there had been a bulletin board with a sheet of the latest news pasted upon it. This was but a trifle scorched about the edges. Nothing was left of the building but a few little stubs of the walls, but this bulletin board was at the corner of the intersecting streets. A cross-draft of cold air may have protected it; or may there not have been created an almost absolute vacuum at such points?

On another building where iron and glass and stone were either twisted or phased out of all recognizable shape, a small glass sign stands undamaged with the gilded letters as bright as new.

The fiercest of the fire seemed to be at the point of the northerly arrow 2, Fig. 6, and there were centered most of the important commercial houses. The fire fed on the factories and manufacturing plants below that point, and there gaining tremendous headway and intensity, swept this commercial district virtually out of existence. "Slow-burning," "mill-constructed," and all kinds of buildings, good and bad, went by the board. The fire seemingly tackled them from the top first, in a quick, blast-like stroke, and then what might be called a *secondary fire* worked horizontally along and burned from the ground up to the point apparently first attacked by the fiercest flames. As Figs. 8 and 9 will show, a few stalagmites, as it were, of walls and piers alone mark the site of these buildings—and only the "skyscrapers" stand in anything like structural entity, splendid monuments to our progress in the science of building.

The work of the fire on such tall buildings as the Continental Trust building, a fifteen-story structure—one of Baltimore's latest and best buildings—may be easily followed. This building was attacked a little more than halfway up, the most intense blast striking it about the tenth floor. I found typewriters and other metallic materials in that story absolutely fused into a molten mass, which means a temperature of 2,800 degrees. It was apparent that blasts similar to the first struck this building later, on the other side from that first attack, but these were undoubtedly of slightly less intensity; then the fire ate away from the second story upward more slowly and then downward. Of course, window frames and glass and the doors and finish, even the floor strips in the concrete, and all the contents of this and the other fireproof buildings, were destroyed. Some of the newspapers in their excitement stated that these buildings burnt as quickly and as completely as the wooden ones, and people, the unthinking ones, generally decry against the *so-called fireproof construction*, because they have discovered by this fire that they were wrong in their ideas that a fireproof building guaranteed immunity to even highly inflammable materials used in its decoration or stored within it. To say that the structures actually burned is, of course, foolish and manifestly incorrect, even to the most ignorant, because they are still standing, and many of them in an easily reparable condition. Take this Continental Trust building, for instance; all the structural steel was incased in tile, and not a bit of it is warped or out of level. The exposed metal portions are twisted into all kinds of fantastic shapes, but the structure itself, the frame, is intact. The structural conditions of all these skyscraping buildings that were built at all within the gen-

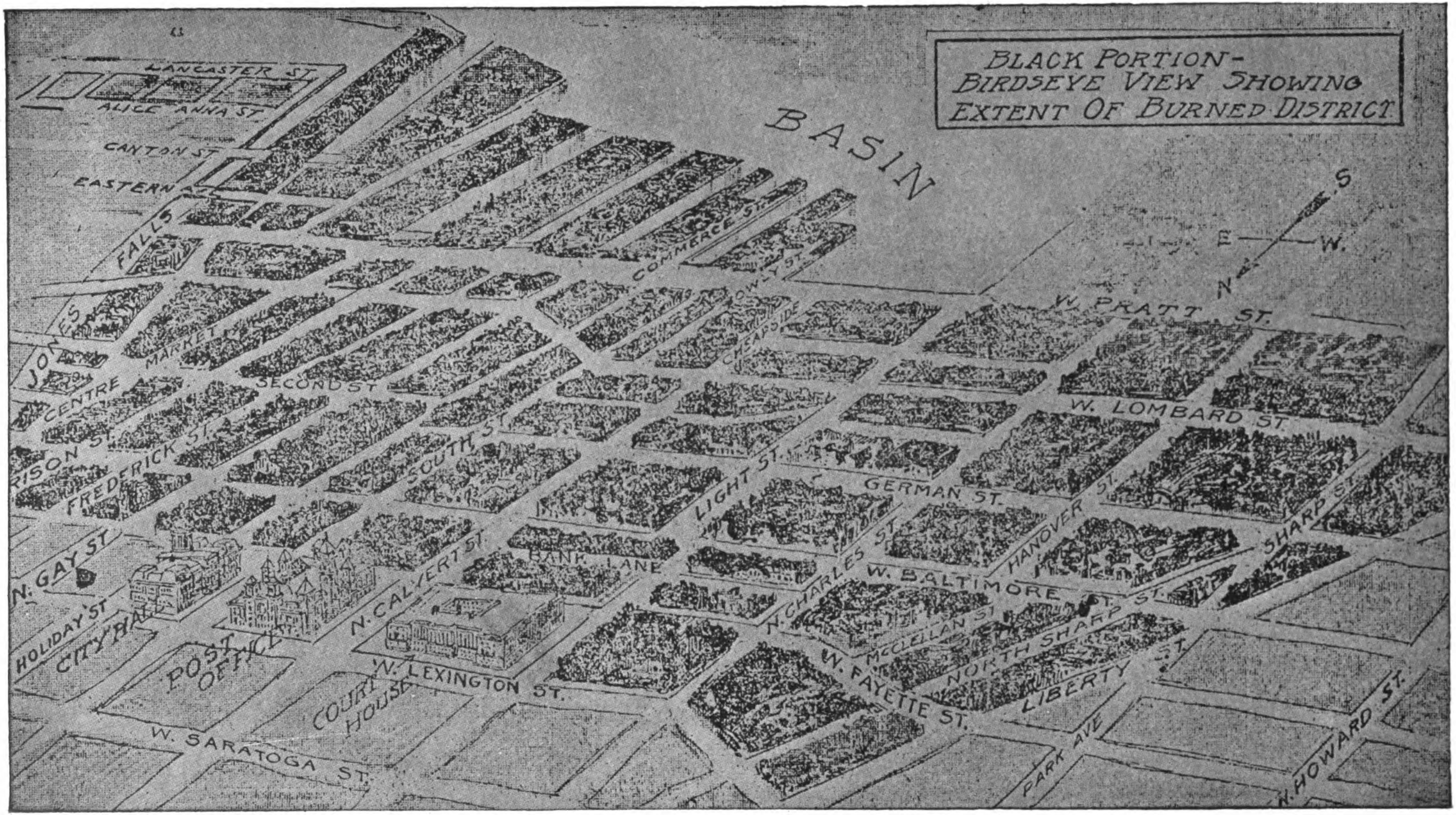


Fig. 10. Bird's Eye View of the Burned District of Baltimore

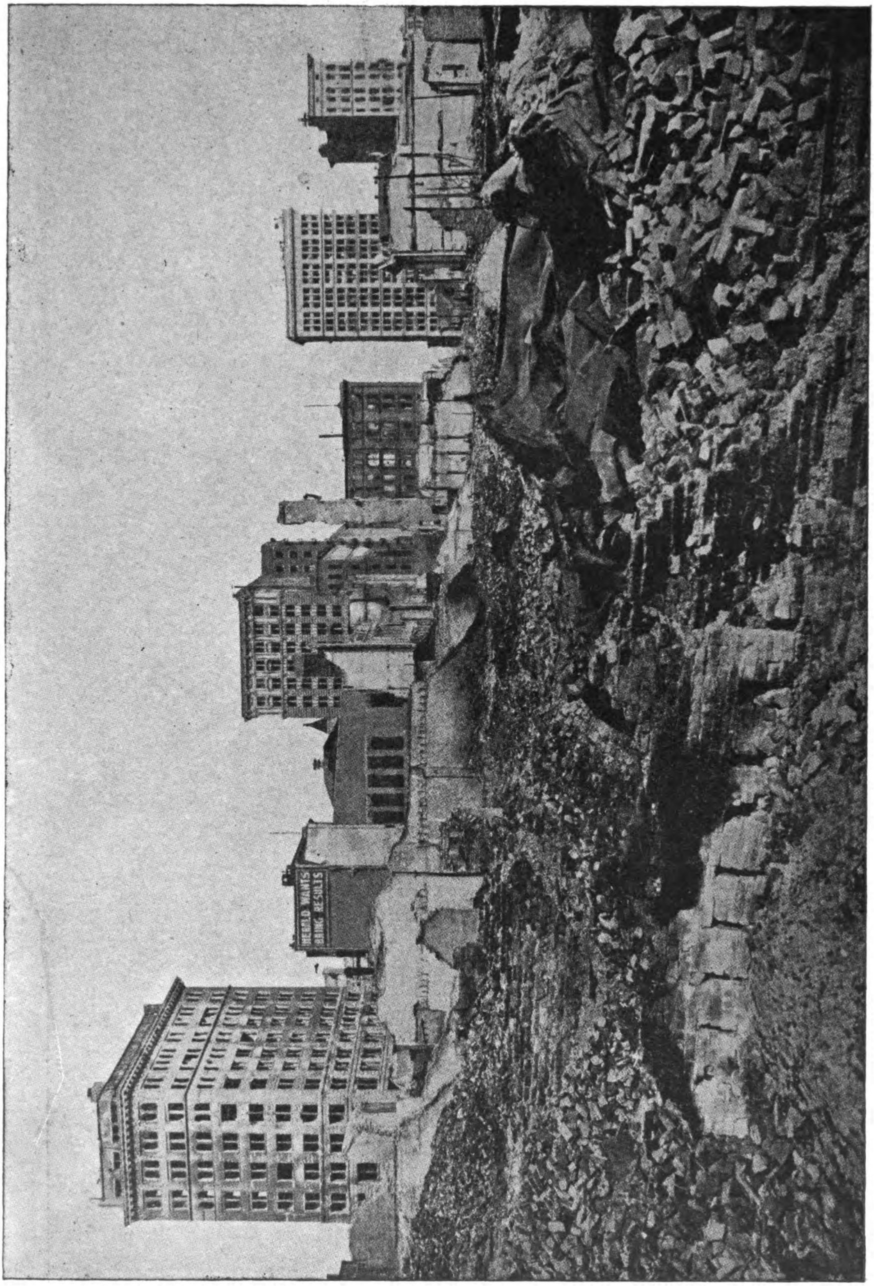


Fig. 11. The Moderately Fireproof Big Buildings of Baltimore
These survived the ordeal structurally and they certainly formed a barrier to the further progress of the fire, but they were scant protection to their contents.

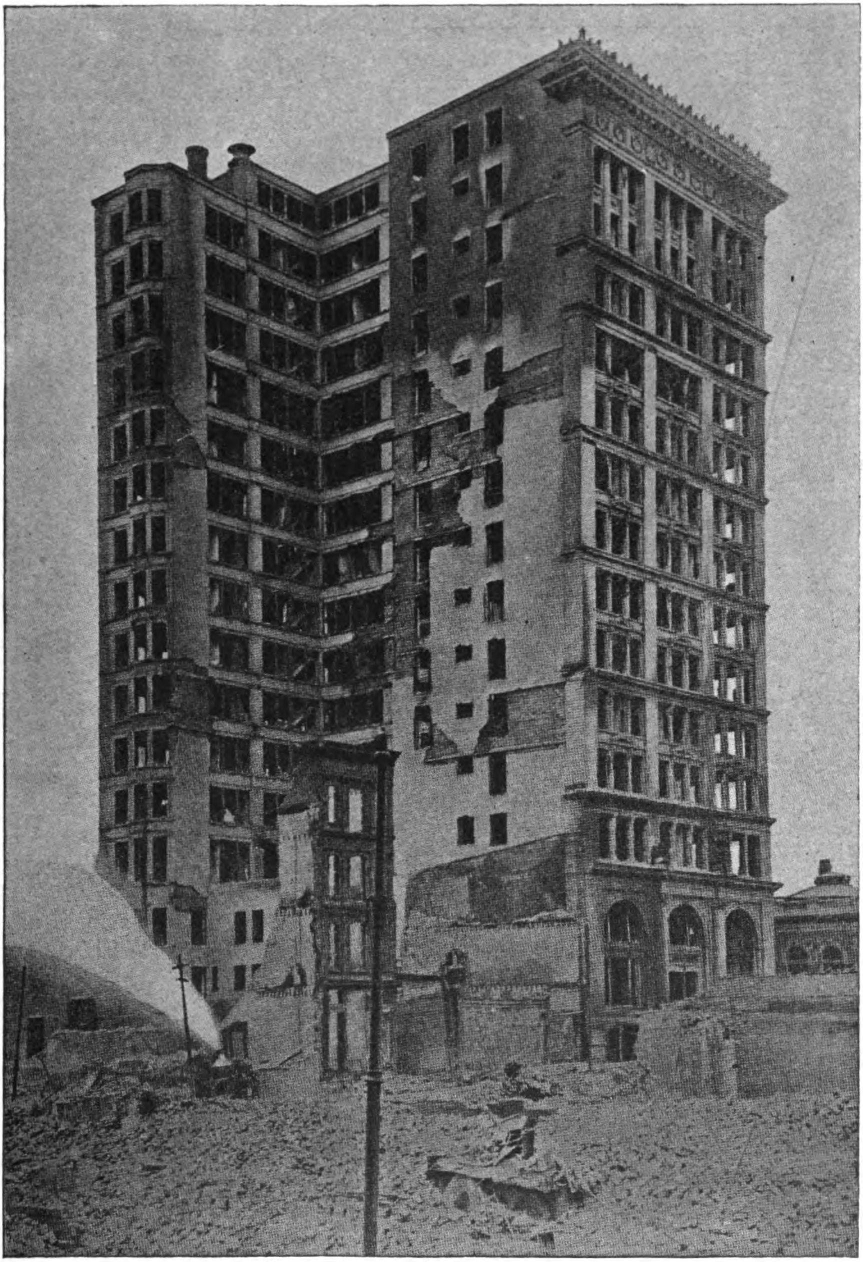


Fig. 12. Unprotected Side Windows Gave Access to Fire; the Interior Entirely Gutted

Fig. 13. One of the Big Brick and Terra Cotta Baltimore Buildings after the Fire The contents gutted but the exterior nearly intact.

eral scheme of our theories of fireproofing, stood the awful test remarkably well. The Equitable building, which is, I imagine, an old building, and one in which, though tile was used, its application was not made along scientific lines, makes a worse showing than any of the others. The soffits of its beams were exposed, the tile arches were segmental, the haunches were not concreted—evidently to save money—and on top of the beams was a heavy two-inch plank floor covered with a finished, dressed flooring. As only a portion of the webs of the beams were protected, the heat twisted and curved these beams all out of shape and necessarily distorted the columns, so that the building will undoubtedly have to be entirely rebuilt. The Calvert, the Herald, the Union Trust, and the Maryland Trust buildings are, as far as their structures go, in fair shape to be repaired, for the steelwork was fully protected by the tile fireproofing.

These skyscrapers were built to contend with ordinary conditions; for instance, if the fire had originated in any one of them, it could not have gotten beyond control, and no one in Baltimore ever anticipated that these buildings would be subjected to any such test from without. Even if such a possibility had been thought of, I venture to state that no one in Baltimore would have been willing to pay the increased cost that would have been entailed had these buildings been erected to withstand any such terrific heat and flame. There are few places in the country where skyscrapers could be subjected to any such test; those in New York and Chicago are surrounded by a better class of buildings than generally obtained in Baltimore. The Washington Post very aptly puts it that a "fireproof building is one that is fireproof itself and is surrounded by fireproof buildings." That, I grant, would be an ideal condition, one that I have long prayed for, and preached for, and yet that definition of a fireproof structure is not essentially correct. Another such conflagration is possible and probable in a city like San Francisco (rather prophetic), or Boston, or New Orleans where great office buildings are found rising from among vast areas of shanties and the most inflammable of structures.

In repairing these buildings in Baltimore and in building new ones of their class in this burnt district, no greater precautions need to be taken, as far as structure is concerned, than we find in the best of the old ones, says the Continental Trust, because presumably a better general class of buildings than the old wooden ones will be insisted upon by the authorities (alas, but little better than the old has replaced them), and in that case no such conflagration could again be possible in that district.

Some people say that this fire proves that an absolutely fireproof building, or one that under such stress would afford protec-

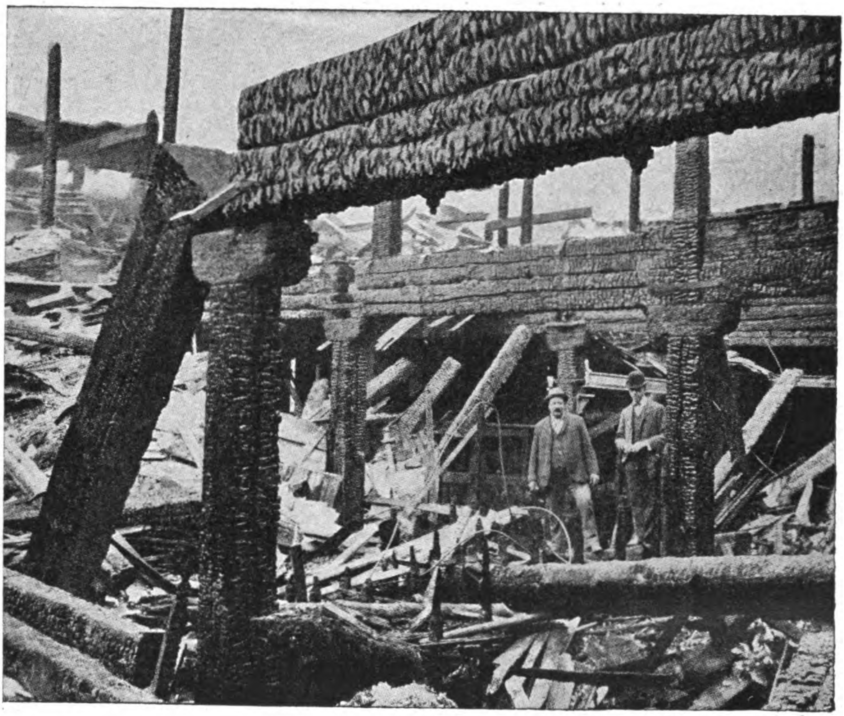


Fig. 14. What Is Left of a "Slow-Burning", "Mill-Constructed" Building after a Fire

tion to its contents, is virtually an impossibility; only the unthinking ones would make any such statement. The people who built the structures we have under consideration, the Baltimore skyscrapers, used fireproofing about their structural parts only. In the finish and all else in these buildings there was absolutely no difference between them and the firetraps that stood all about them and which have now disappeared from off the face of the earth. Insofar as that fireproofing went, it has been eminently successful, and this

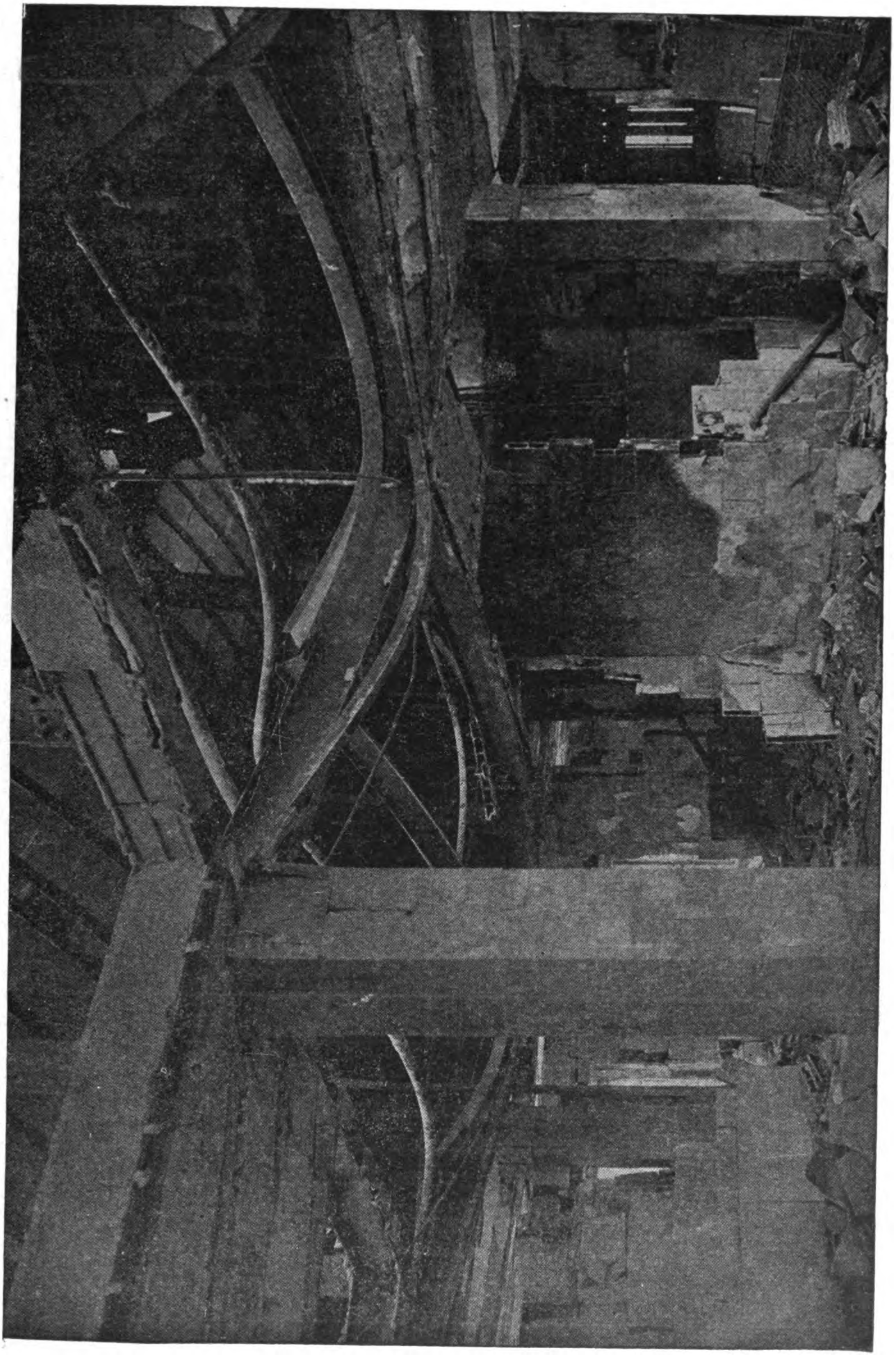


Fig. 15. The Improper or Inadequate Protection of Steel Work Always Results in Deflection and Collapse

terrible fire demonstrated its value more forcefully and potently than anything that has happened in the past twenty years.

Think of the test the steelwork was subjected to! Imagine dropping a lot of closely bound and connected metal, very susceptible

Fig. 16. A Baltimore Street After the Fire

to variations in temperature, into a furnace where different parts of that metal would] be subjected to a temperature of 98, 400, and 3,000 degrees at the same time, and remember that that metal was encased in sometimes not over one inch of tile and that its parts were not warped, disjointed, or otherwise damaged by that terrific heat test. At some *one* time those tall buildings underwent about those variations of temperature. Realizing this and having those buildings

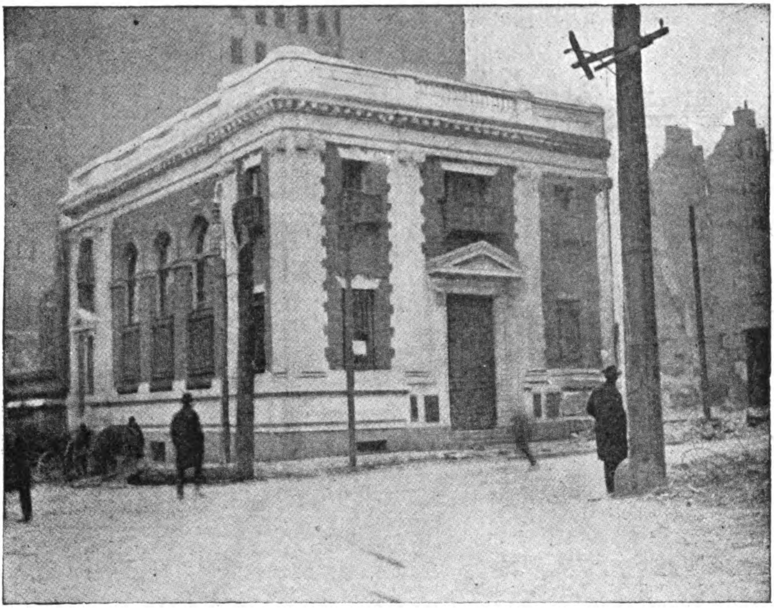


Fig. 17. The Alexander Brown Building
Almost intact, protected with wire glass, a veritable oasis in the desert of fire waste.

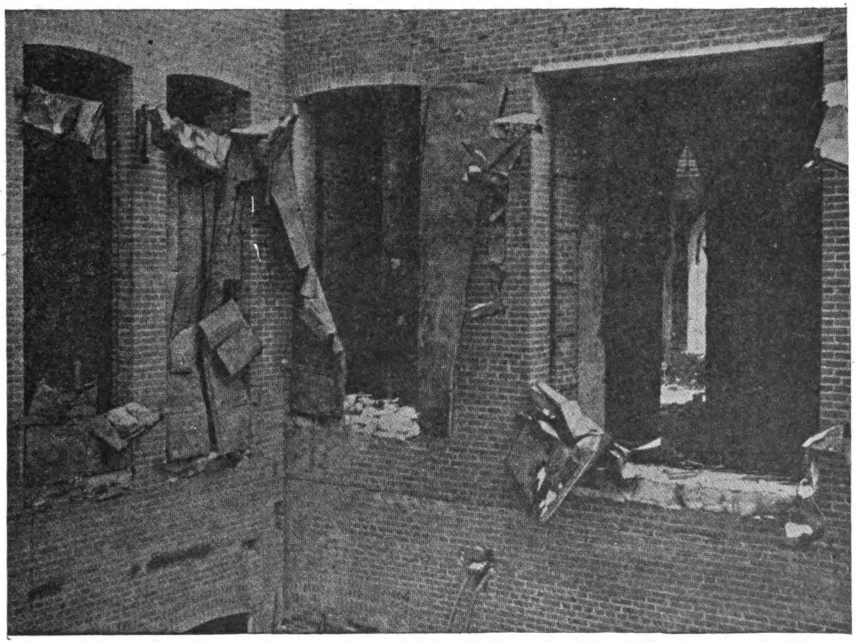


Fig. 18 Ineffective Fire Shutter Protection

standing before us in splendid proof of their stability, how can anyone making claim to the possession of even ordinary intelligence state that "fireproofing" is not fireproof?

The great fire of Chicago in 1871 had for its effect throughout the country the barring of frame buildings within certain limits. This great fire of Baltimore is another step in the popular education, and will result in people doing more thorough fireproofing in structural building and using less damageable materials in exterior and interior decorations. But this education is slow, and enormously costly. It will take another such terrible experience (and it did) to thoroughly impress the people with the fact that we so-called cranks on construction *are* right and are not making unreasonable demands in the line of improved methods of building. We realize and appreciate the possibility of such great conflagrations, but people call us "croakers" until the things we foretold actually do happen. Then they come to us and tell us how clever we are and ask our advice as to how *they* should build, and because, forsooth, our way costs more money than they care to expend, they erect the flimsiest structures the too "complacent" laws will allow. Judging from my mail these days, both architects and laymen have experienced a change of heart and are anxiously and insistently desirous of advice how to build *well*, rather than cheaply—but the desire will last only a few weeks, or months, perhaps. City laws *compelling* people to build well are our only absolute safeguard—good laws well enforced by competent zealous officers are the solution of the building problem.

THE SAN FRANCISCO FIRE CALAMITY

It is said that surgeons must necessarily become hardened to the sight of human suffering; presumably, too, one, a part of whose business it is to examine into all the tribulations of building, must grow accustomed to the sight of devastation as the result of human stupidity or carelessness. I have seen the effects on buildings of all the great disasters of the past twenty years, and approached San Francisco fully prepared not to be surprised at the extent or degree of its calamity. But the panorama that deployed itself before me when I first gazed upon the stricken city from its highest point was enough to make any man's flesh creep—a hundred Pompeiies gathered upon one site; the Baltimore wreck, awful as that was, magnified fortyfold!

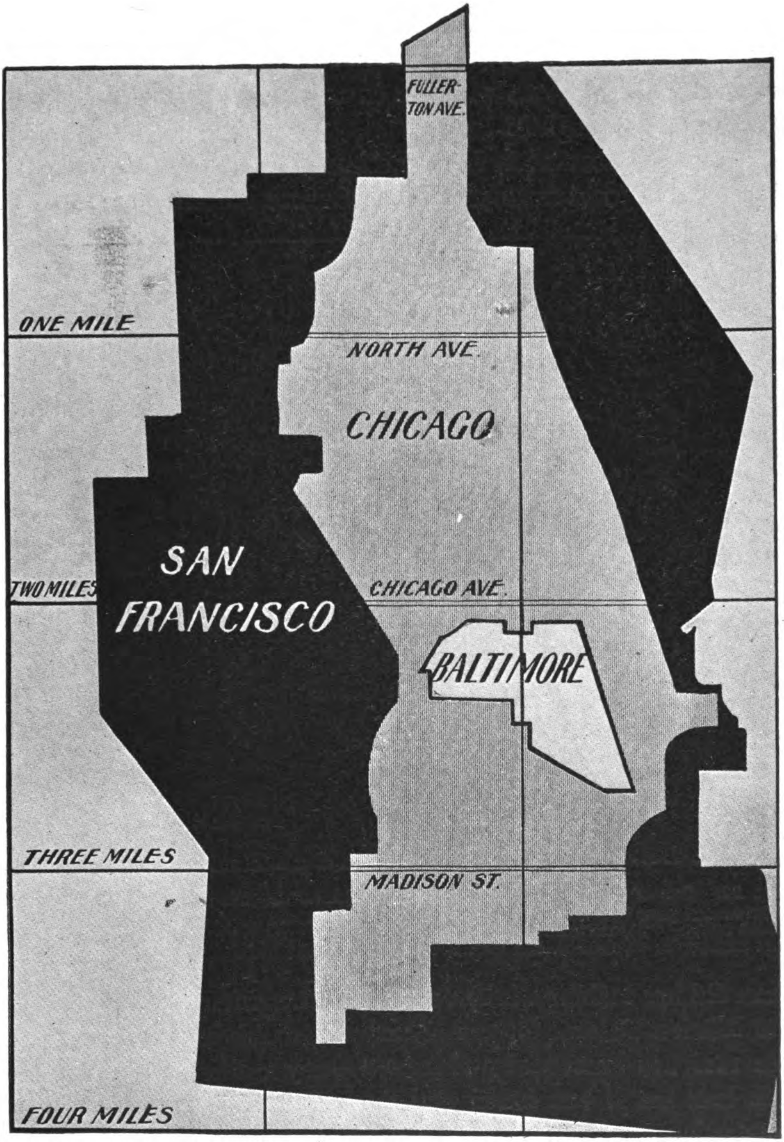


Fig. 19. Comparative Areas of the More Recent Historic Conflagrations.

The suffering of the people, the heroism and rare skill shown by a few coolheaded leaders, the good work of the military, and other dramatic and soul-stirring features of the story, have all been well and repeatedly told in the daily and periodic press. This report must needs deal alone with the structural conditions of the city, a subject vast enough in itself.

As with most cities, San Francisco grew up from a shanty-town into a city of great commercial importance at a much more rapid rate

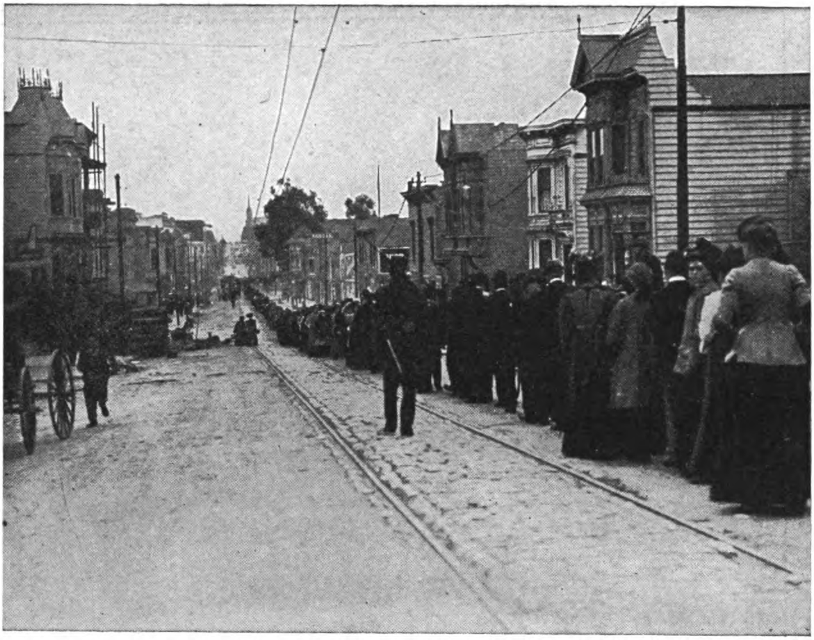


Fig. 20. One of the Many Mile Long "Bread Lines" in San Francisco after the Fire Rich and poor had to be so fed on government rations for days until regular supplies could arrive. All this suffering and loss of property entailed by that fire can, with perfect justice, be charged to the poor construction of the buildings.

than did her buildings in the scale of metropolitan excellence. The old Mission Dolores Church of early days with its adobe walls and tile roof has successfully withstood every earthquake shock, even this last, but it was found that the indifferently made bricks and mortar in vogue in the '50's and '60's, or thereabouts, were an easy prey to every quake, and the popular verdict was, therefore, that wood could best withstand the buffetings of old Mother Earth—wood to remain in place at all had to be well-nailed, and therefore it would hold together while bricks could be stacked up with but the semblance of mortar in their outer joints—a delusion and a snare. Wood was therefore used in even the most important buildings, being made to imitate stone for appearance's sake. Then, little by little, real stone and brick were again used for external walls, for it became evident that in the congested district this sop to fire-retarding was quite essential; still, the wood framing and tenpenny-spiked bonding obtained as far as internal structural parts were concerned. It is less than twenty years since Californians were first induced to permit the construction of a steel frame building; the law did not compel it; and in fact, the authorities looked askance at tall, steel construction as constituting a menace and certain danger in the case of quake. Since then, perhaps fifty buildings have been erected under the name of "fireproof construction."

In these tall buildings one thing has generally been done well, the steel frames having been exceptionally strongly built and extra braced with what is commonly known as "wind-bracing"—a precaution against quake. Apart from that, absolutely no extra care was taken; the stone setting, the brickwork, the fireproofing of the structure, and the other safeguards against fire—these latter chiefly conspicuous by their absence—were in no case superior to our better class of construction in the East. It would have been reasonable in those large buildings, at least, on account of quake and conflagration hazards (San Francisco and New Orleans were two cities in which the latter seemed most probable and would be most far-reaching, the buildings being fully 90 per cent frame), to expect a general construction of from 14 to 30 per cent better than we use in New York and Chicago, where the first hazard is hardly to be expected and the second is a somewhat remote contingency. As a matter of fact, with rare exceptions indeed, even the best San Francisco buildings were from 15 to 50 per cent poorer in design and construction, from a fireproof engineer's point of view, than our best buildings in New York, Washington, and Chicago. And as for the secondary buildings, I doubt if any city in the country made less provision against fire and quake than did San Francisco

The building laws were lax and, in plain English, the architects either knew little or cared little about fire protection; builders made the most of this laxity, and manufacturers—in keen competition among themselves and against the outside—made their materials accordingly. No one thing or group of people need be blamed for the result. The conditions were general and laxity and recklessness were local characteristics.

Local brick was only fair in quality; the lime mortar generally used was not of superior grade, and what little cement mortar there was, had for components a pretty fine sand and a very inferior cement. There are, of course, exceptions to all of this arraignment—I am speaking now in general terms of the conditions as I knew them and found them to exist in the greater part of the work done in San Francisco. Architects seldom sinned on the safe side of steel construction. Gusset plates and rivets seemed an expensive luxury, save in the few very tall buildings that were "wind-braced"; the fireproofing tile protection, particularly of columns, was exceedingly thin, invariably of dense tile (generally also inclosing steam and other pipes), put together around columns with merely galvanized iron U's, generally forming part of partitions, never tied to the column or with a mass of filling tile or concrete in the voids of the column; beam soffits were sometimes entirely exposed and seldom had more than a $\frac{3}{4}$-inch slab; partitions were light, of dense tile, none too good mortar, and no other bond than the mortar; tile floor arches were generally of side construction or other obsolete forms and seldom of sufficient depth to withstand earthquake shocks. In no building was the steel work thoroughly covered with cement as a protection against corrosion, before being enclosed in fireproof protection. None of this fireproofing, in shape, manufacture, or particularly in application, was at all equal to the best work now being done in the East. There was no call for it, and any manufacturer will give only what the market demands, particularly when he has to compete with cheaper, inferior products. Yet wherever tiling was even *fairly* treated in construction, it in every case performed its functions well. Many buildings show evidences that the steel work did not receive a second coat of paint.

The concrete used in floor and other construction was generally made of local cement, of very inferior quality, while the reinforcing systems most in vogue are not now regarded as being up-to-date, are scant in metal and overwide in span without rigidly riveted steel ties. Fortunately, most of the concrete floors were protected with a suspended metal and plaster ceiling that more or less successfully parried the first fierce blast of fire, a protection, however, that proved

THE NEW SAN FRANCISCO.

Fig. 21.

itself there, as everywhere else, grossly inadequate when applied directly to steel members.

Metal and plaster partitions predominated; tile partitions were set upon the wood strips and concrete filling of floors; in all these tile partitions there were wood strips for wainscoting and skirting board, wood jambs for doorways, and wood lintels and sills for

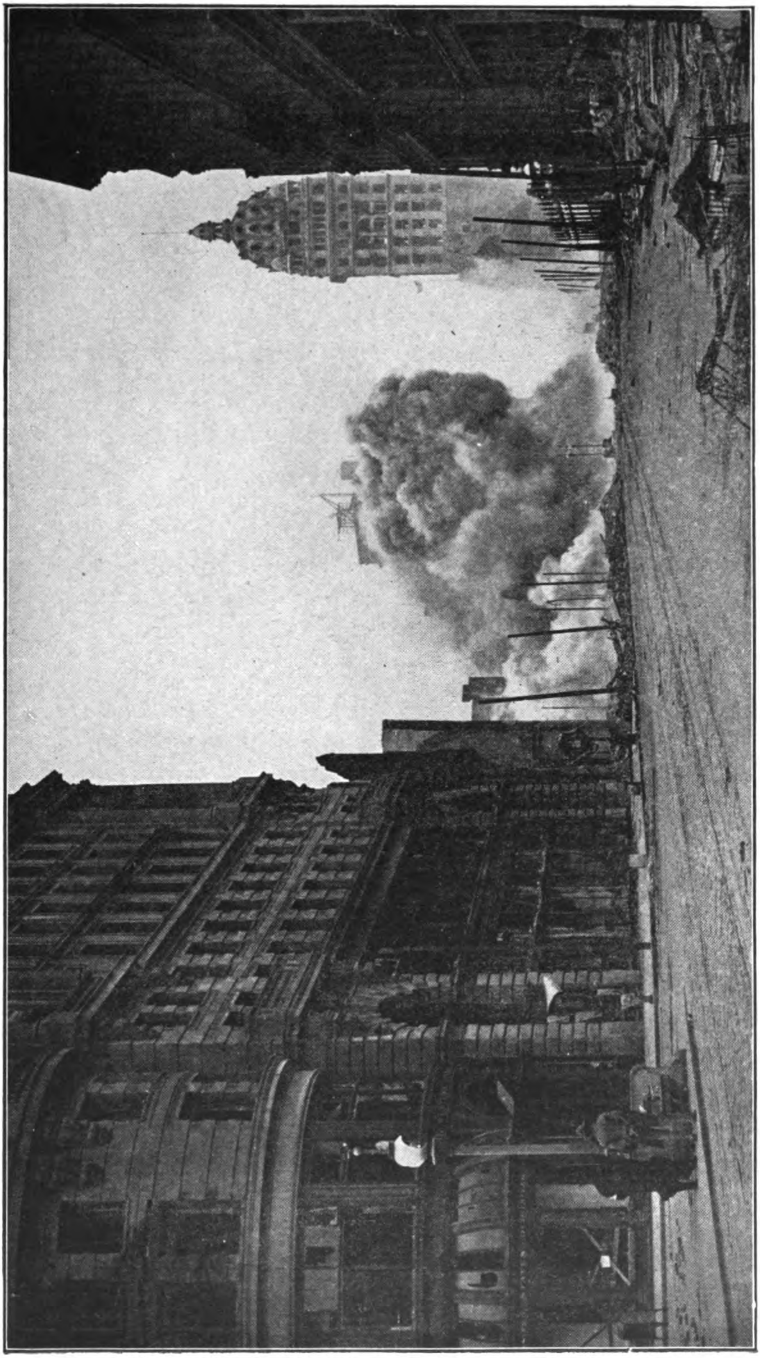


Fig. 22. Fighting Fire with Dynamite at San Francisco

corridor lights. In every case but one, the tall buildings were trimmed entirely with wood. In no case were stairs and elevators cut off. None of the big buildings were sufficiently, or indeed, at all, protected with wired glass, or even shutters. In lamentably few cases was there any attempt at an adequate local supply of water. Generally speaking, the big buildings were fireproof only in that their steel frames were more or less effectually protected from fire and that their floor construction and partitions were not of wood. That one act was deemed sufficient to impart "immunity" to all the inflammable remainder of the building! In all else they offered as little resistance to quake and fire as did the second and third

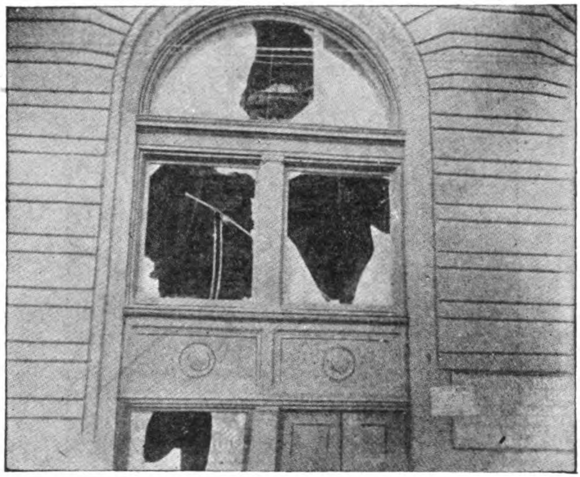


Fig. 23. The Inadequacy of Ordinary Glass
Fire went through these windows as it would through paper.

and fourth classes of buildings, though vast expenditures were made by architects for much carved stone, highly ornamented terra cotta, rare marbles, and other accessories that people have been taught to term *architecture.* The second and other classes of buildings were but mere shells of brick and stone or wood with occasionally an exposed iron beam and a cast-iron column, but whose carrying parts generally were all of wood, without cut-offs or the faintest semblance of provision against fire or quake.

That, in brief, is a fair picture of San Francisco on the 17th day of April, 1906. A picture as unattractive could hardly be painted of any city in the East or Middle West, and yet San Francisco has always been known to be subject to very severe earthquakes and more than ordinarily exposed to fire. Her fire department was a most excellent one, and therefore the insurance companies abetted her in her sins by writing foolishly low rates on her very flimsy buildings. Surely her people have paid the price for their sins of omission—for they say that ignorance is no excuse at law—their archi-

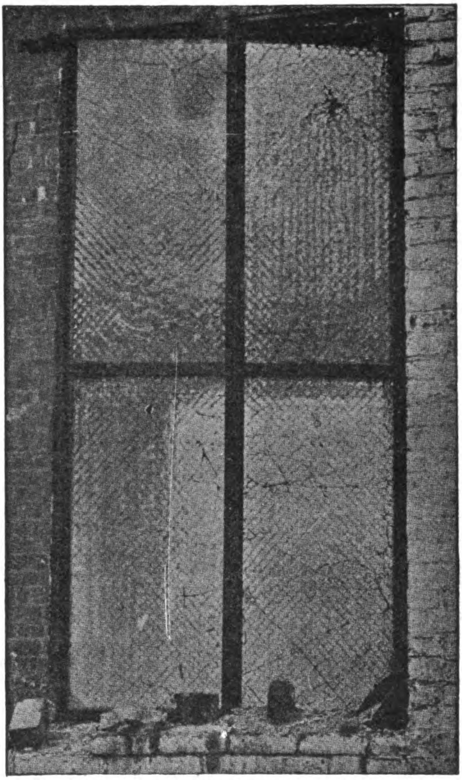


Fig. 24. Wire Glass After a Fire
Note that some molten glass has run down upon the sill, yet fire found no ingress there.

tects' sins of commission, and the authorities' worse than criminal neglect. The lives of hundreds of her citizens were cruelly wasted (the exact number never will be known, but I am positive it far exceeds the official returns); the waste, the actual destruction of property into ashes and smoke must certainly reach far in excess of $300,000,000 (with probably $200,000,000 insurance, settlement of much of which will have to be by litigation, that in all probability

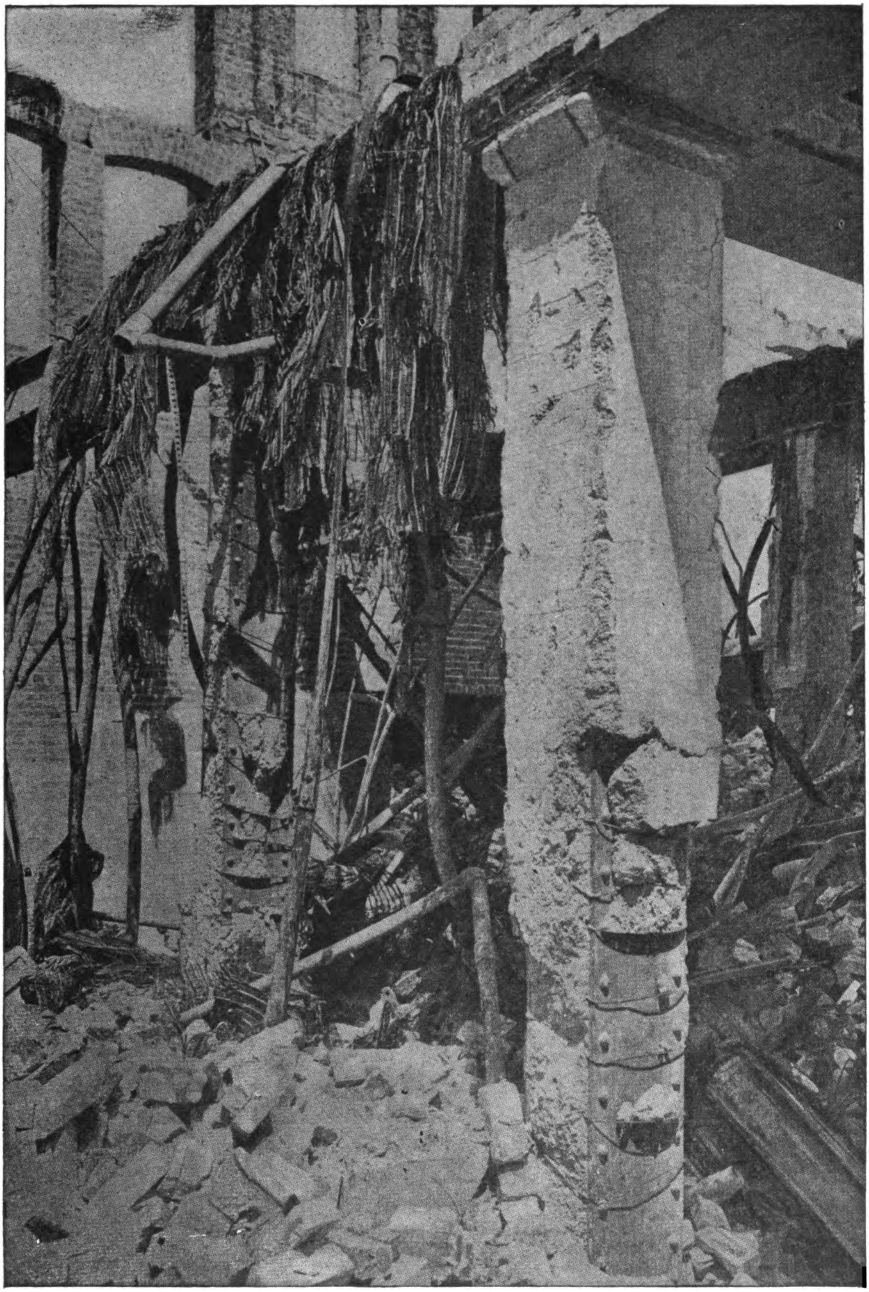


Fig. 25. Ineffective Fireproofing After a Fire

will decree that about $140,000,000 be paid the policy holders), while the indirect loss in business, in time, and in values to the city

Fig. 26. Fire's Ingress via the Window Route
This, the San Francisco Call building, was fairly isolated but fire literally jumped across the street at it, entered through the lower windows, consumed all there was in it that could be burned and the smoke and flames were carried up and out the upper windows as if the structure had been one vast chimney.

and to the nation at large can only be told in a figure of ten digits.

The story goes that at 5:30, or immediately after the quake a lady living at Gough and Hayes streets, wanting a cup of coffee, lighted a fire in her kitchen stove that vented into a damaged chimney and set fire to some adjacent woodwork. At all events, the consensus of opinion is that the first fire originated not far from St. Ignatius Church and that the wind, though being but a slight westward breeze, fanned the fire toward Market Street. Whether that was the first fire or not matters little, for it is pretty well established that within a few minutes after the quake there were fires well started in at least ten different places. The water mains had been broken by the quake and though a gallant fight was waged the fire was soon beyond all human control. The people made little stand against it, they were panic-stricken and fled. The fire department could do but little. Its chief had been mortally stricken by the earthquake. He was a splendid executive, but held too much in his own hands. He had expected just such a calamity, had begged for a salt water supply downtown, had studied out the city as a chessboard and knew just where he would use dynamite to the best advantage; he realized that there was abundant water in the sewers and had planned to use that in case of need. Had he been on duty, good general that he was, it is barely possible he might have confined the flames to a more restricted section. The sub-chiefs were not accustomed to great executive duties, and no one had the initiative or could think of the expedients he had planned and undoubtedly would have resorted to. Military, police, and fire departments took a hand. Dynamite was used, but foolishly, for as in all great crises, some men "lost their heads." In some cases, buildings actually on fire were dynamited, thus scattering ignition in a hundred directions; instead of blowing up small buildings to make an open space and letting fire waste itself in the big buildings where there was comparatively little to burn, several of these tall structures were dynamited—an action that in no way retarded the fire, but that caused infinitely more damage to these expensive structures than either quake or fire or the two together. It is doubtful if even at Van Ness Avenue dynamite did very much good. Of course, in such a fire fierce currents and drafts are created, but at no time during its duration was there any tempestuous wind such as prevailed at the Baltimore fire. Then, too, most of the wood used, unlike in Baltimore, was not over-resinous in nature, so that the fire, while fierce

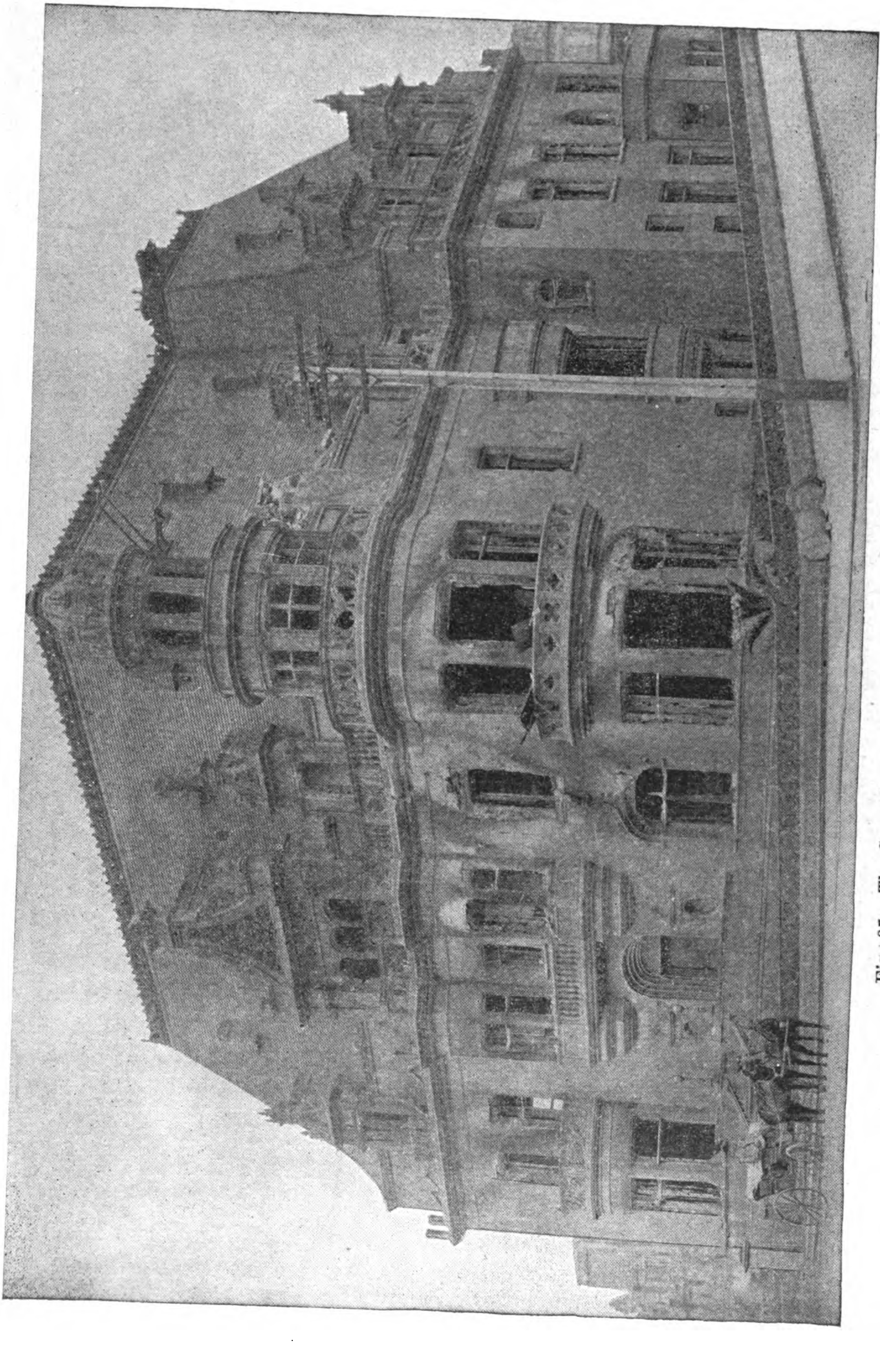


Fig. 27. The Spreckles Residence, on Van Ness St., San Francisco
This residence is just on the edge of the fire district; is partially fireproof and resisted fairly well.

Fig. 28. Showing the Effect of Fire Supplemented with Dynamite

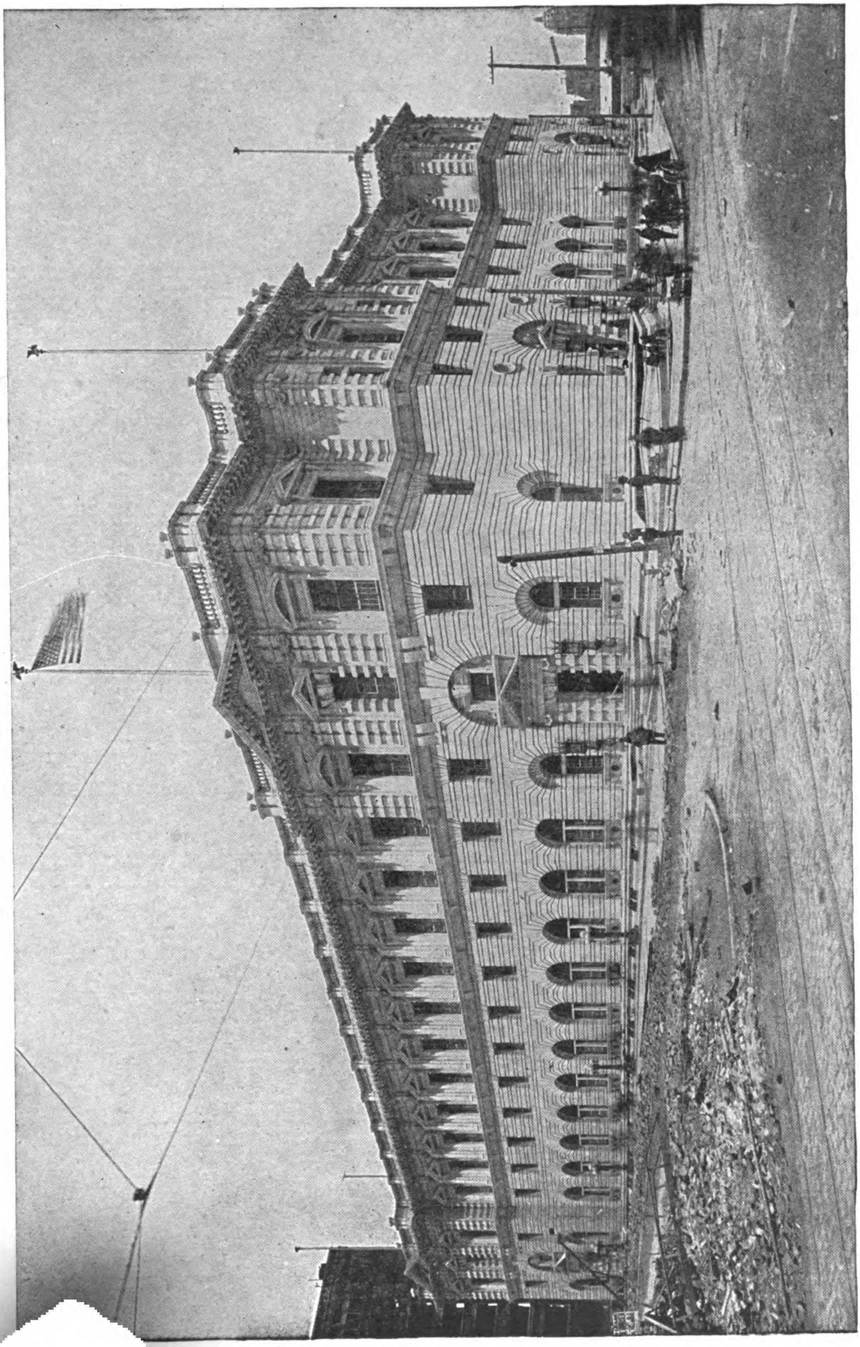


Fig. 29. The United States Post Office at San Francisco
Showing results of good construction, comparative isolation, and the fidelity of a few employes who fought the fire there. It was but slightly damaged.

indeed, was much slower, steadier, all-absorbing, and developed at only a few points temperatures as high as were shown at Baltimore; there was less of the "blow-pipe" effect.

At Van Ness Avenue the fire encountered a very wide thoroughfare, a breeze from the west, and a solid stand of defense. The people were in the last ditch, as it were, and though exhausted, fought every inch of fire with wet blankets and whatever they found at hand. In the extreme southwest of Market Street the fire extended up to Dolores Street, but there it died out or was conquered.

Here and there in the stricken district are what seem to be oases in the desert. A half-dozen blocks on the water front between Lombard, Montgomery, and Green streets were comparatively untouched; then again on a hillside around Vallejo and Jones streets, "Telegraph Hill," there are a few dainty residences and green trees. The old Appraisers' Warehouse and its immediate vicinity are comparatively unscathed, while the Postoffice, the Mint, and a few other isolated buildings show where there were some local water supply, tanks, etc., and where a few devoted employes fought the good battle to victory.

In the downtown district the fires were erratic, they would glow and fiercely consume some buildings, in others, where there was seemingly as much combustible material, they would dim and smoulder. There were pauses at some of the big buildings, almost extinction; then gases would ignite in those great piles, lighted via the unprotected windows, and everything burnable within them seemed to be on fire at one time. Popular verdict has it that the Call building was "red hot" and glowed like an ember.

The government buildings stood well apart and isolated, which, of course, was an advantage. The Postoffice, one of the best built buildings in San Francisco, if not the very best, was very little damaged by the fire, in fact on the interior not enough to interfere with the workings for even a day, while on the exterior only some of its granite work was a bit scaled off. However, as the building was on made ground, the damage from quake and dynamiting was considerable. One or two arch stones are thrown bodily out of place, the great granite piers in front are here and there cracked angle-wise across their faces; in the projection of one pavilion is a vertical crack nearly halfway down and 3 inches wide, showing that the front has been pushed out, but fortunately there were ties and bonds and the repair will be easy. On the Mission Street side the street has

Fig. 30. The Great and Handsome City Hall Before the Earthquake and Fire

sunken fully 4 feet and carried with it steps, terrace, and base of the building. The fissures in this structure, as elsewhere, have not followed the joints by any means, but have started at a joint and gone clear but raggedly through the other stonework, and there

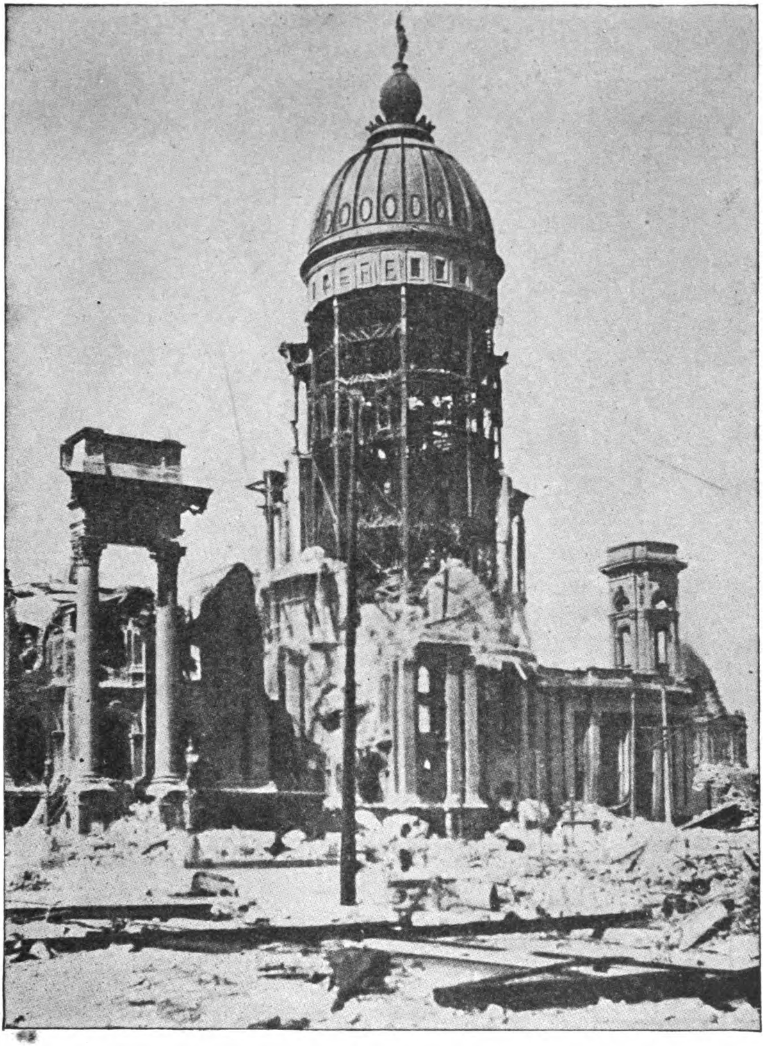


Fig. 31. The Great and Handsome City Hall After the Earthquake and Fire
A tile floor had recently been put into the top story and apparently that cut off the fire from destroying the top of the dome.

are usually two or three cracks in the same general direction. Internally, the glass throughout is pretty badly shattered, the plaster-

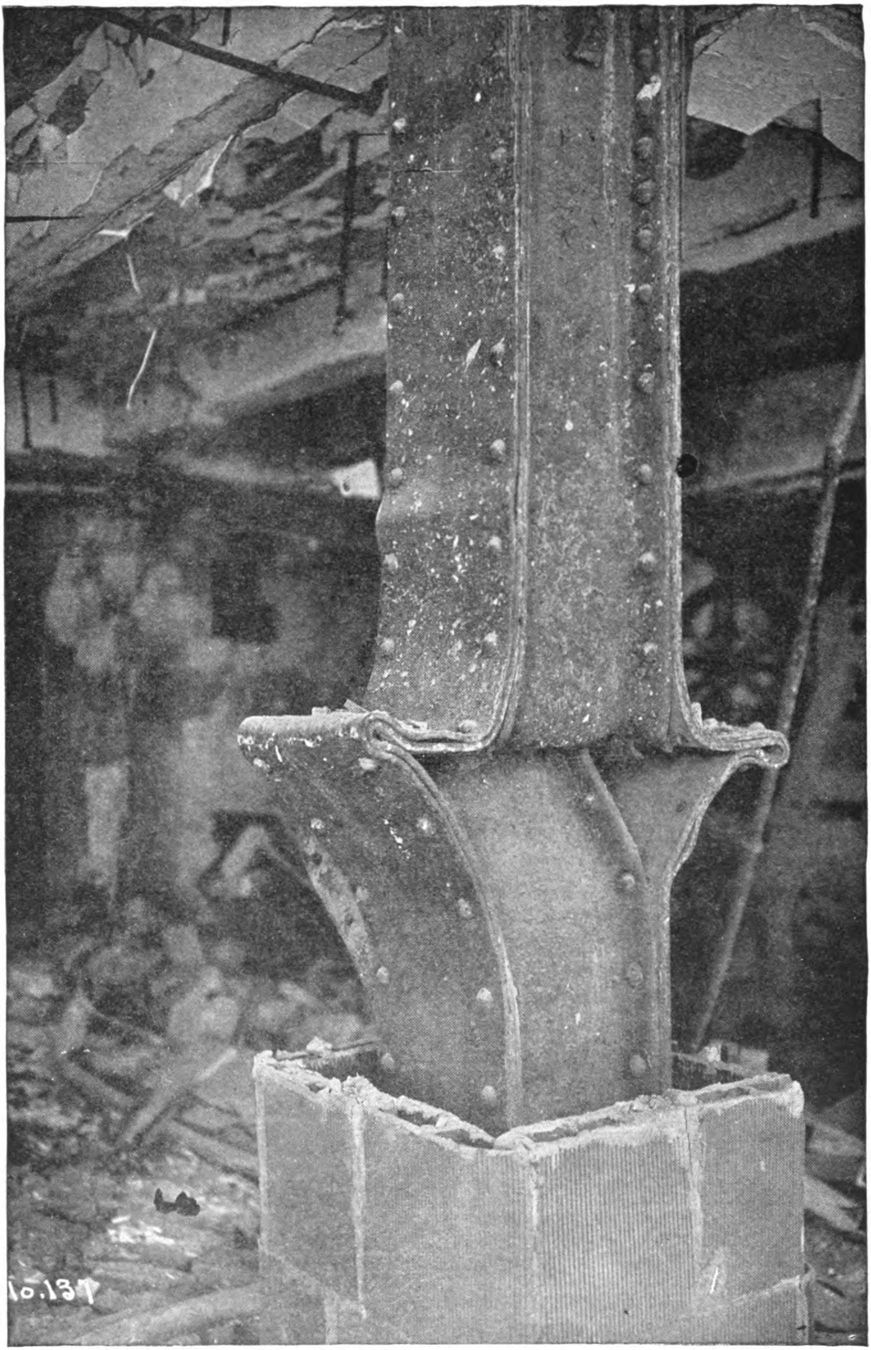


Fig. 32. Improperly Placed Hollow Tile Protection
The steel column when heated crumpled up under its load and caused much damage.

ing is cracked at the lintel lines over the doors; whole sections of marble wainscoting are thrown out, but no tile partitions are displaced or internal structural parts wrecked. The employes say that they had the building all cleaned up and in working shape by Sunday night after the quake, but that the blasting of Monday morning did a goodly part of the damage now noticed. The repairs to the Postoffice will certainly involve $100,000 or more. In the Appraisers' Warehouse and the Mint they fought the fire with hose, wet blankets, gunnysacks—anything at hand; glass was shattered, some plastering gone, and here and there rooms were a bit scorched but the damage is not severe. Ancient forms of construction obtained in these buildings—good big brick walls, iron beams and brick floor arches, showing scant signs of any disturbance.

The City Hall was a very large, imposing, and somewhat artistic building, but cruelly poor in construction. The outer walls were of brick, covered and ornamented with stucco, while the structural parts were of iron or steel, having segmental floor arches of corrugated iron plates covered with a miserably poor quality of concrete and protected by a suspended ceiling. Some partitions were brick, some were tile; much of the iron work was unprotected. The earthquake wrecked it badly, fire completed the task, and the only thing that can be done with it now is to tear down what is left and clear off the site.

Some idea of the severity of the shock may be gleaned by an examination of this building. The portico columns were great affairs fully 4 feet 6 inches in diameter and over 30 feet tall, cut up by drums 8 feet or so long and composed of a shell of cast iron an inch thick, filled solidly with tons and tons of concrete. These columns, at least many of them, lie flat in the street and many feet from the building, the tons and tons of weight not simply pushed out from the top by crushing roof or anything of that kind, or teetered off their bases by a shaking motion, but literally "kicked off" and well out from their support. This building cost millions of money and was undoubtedly the plaything of grafters. Even in the parts not burned the concrete is so poor you can pick it out of place; and where fire touched it at all, all life is extinct and you shake an entire section by walking across it. Most of the wreckage lies toward the west. The cast-iron framing columns are badly warped and

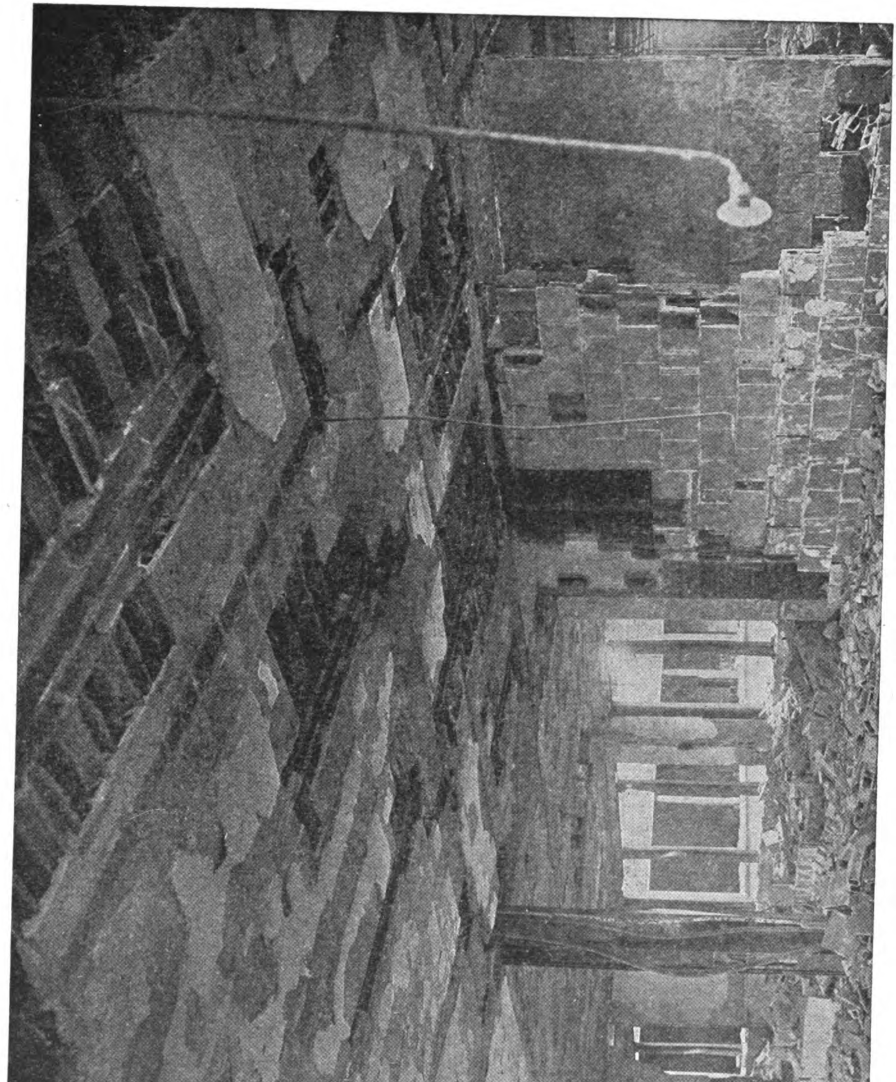


Fig. 33. Too Thin Shelled Tile Wall Sometimes by Reason of Unequal Expansion "Throw" Their Soffits Thus in a Fire

twisted, though in places the molded capitals are barely scorched; the metal in the cornices and decorations outside is either entirely off or so blistered and crumpled as to be useless. Here and there are slight evidences of good workmanship; one might almost call them spasms of virtue in careful superintendence. Where the brickwork was well bonded and good cement mortar used it held so well that though thrown out of place or carried out by the wreckage there are great chunks here and there, 4 feet and 5 feet cubes, as homogeneous and solid as any rock. Even the concrete in places was well done. I found a section 4 feet by 10 feet that had fallen three stories and was still a pretty fair slab. The dome, with all its columns and ornamentation, is a shattered mass of débris, save its steel frame that supports, high in the air, a tile floor, the top story of the dome, above which everything seems to be in pretty fair shape!

It must be perfectly evident to even the layman that in the strict sense of the term there were no fire*proof* buildings in San Francisco. It has been demonstrated to the architects and people of San Francisco, if they did not know it before, that the mere fireproofing of the steel work, putting in this or that material in the floor construction, does not constitute a heavenly dispensation to construct every other part of the building in a way which is no better than that used in the veriest firetrap. So it must be evident that where the fireproofing of the structure was well done, that structure has not suffered; that where the interior fittings were of non-inflammable material, as in the Kohl building, incipient fires inside of the building found little to feed upon and were easily extinguished; that where there was much of the inflammable in the construction and occupancy of a building, but where its windows were protected with wire glass, as in the California Electric Supply building, and the attack from fire was altogether external, the interior of the building and its contents were saved; that where there was any local water supply, little material to burn, intelligent or trained employes in charge, as in the several government buildings, fire could be successfully fought; and that, had there been any buildings there, which were cut up into small units by impassable fire barriers or in which stories were isolated by stair and elevator wells being enclosed, fire originating in any of the units could not reach or damage the others. Now then, with all this before the San Francisco people—even if they had absolutely no regard for the warnings, the preachings we have been carrying on for years, the reiteration of these very things—is it not reasonable to expect that they will assemble the features of construction that have severally proved themselves sane and reliable, into one complete system of construction and establish that as a standard of proper building?

It would be most wise, true economy—an approach to the ideal condition of municipal government—if such a standard were made *obligatory* in the new city. But with the government as it is, such municipal Utopianism is absolutely out of the question. The architects in the past certainly did not rise to the situation, and the chances are ten to one that they will continue to build anything a man wants and with just as scant provision against destruction as the exceedingly lax laws will permit. Therefore it is really up to the individual owner of property to be discriminating, to judge for himself, to know something about construction and to direct what he wants to build. Surrounded as his building must long remain, by shacks and even tall buildings of questionable construction, it must be perfectly obvious to him that his sole salvation lies in the protection he is wise enough to give his own property. He must needs build his warehouse, office building, store, club, or residence so that it will suffer the least possible damage in a conflagration scarce one whit less severe than this last. If people talk insurance to him as a possible salve he must remember how little of the sore that salve actually covered in the later disaster and he must also remember how costly it is—a salve that has cost us $1,610,880,000 for premiums in ten years—and that a building really well constructed and designed is virtually its own insurance, and though its first cost may be a trifle greater than if he builds in the usual manner, its ultimate cost in actual dollars and cents is *far less*, and when he sees his neighbor's flimsy building disappearing in fire and smoke he will feel that the extra cost of his own building for its proper construction is *absolutely clear profit.*

The burned area equaled 4.7 square miles, or 3,000 acres, or 520 blocks. The fire destroyed 28,000 buildings along 36 miles of streets.

In all that great city there were thirty buildings whose designers knew enough to at least attempt the fireproofing of one feature,

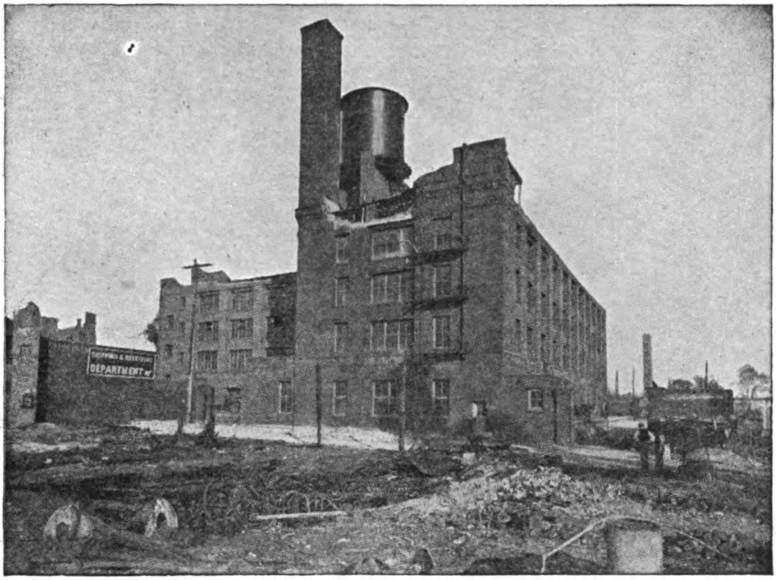


Fig. 34. California Electric Building
This building was saved by wire glazed windows and two faithful employes, though the building was an inferior one and in the thick of the fire.

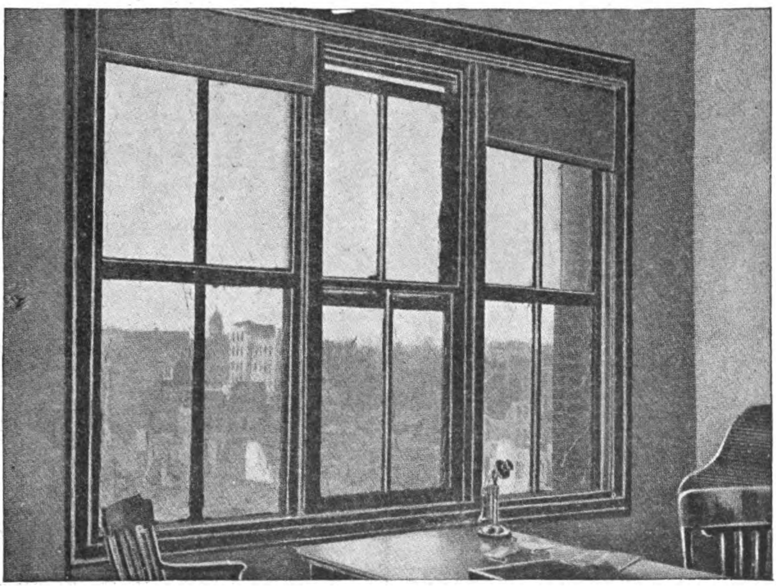


Fig. 35. The Windows That Did the Protecting

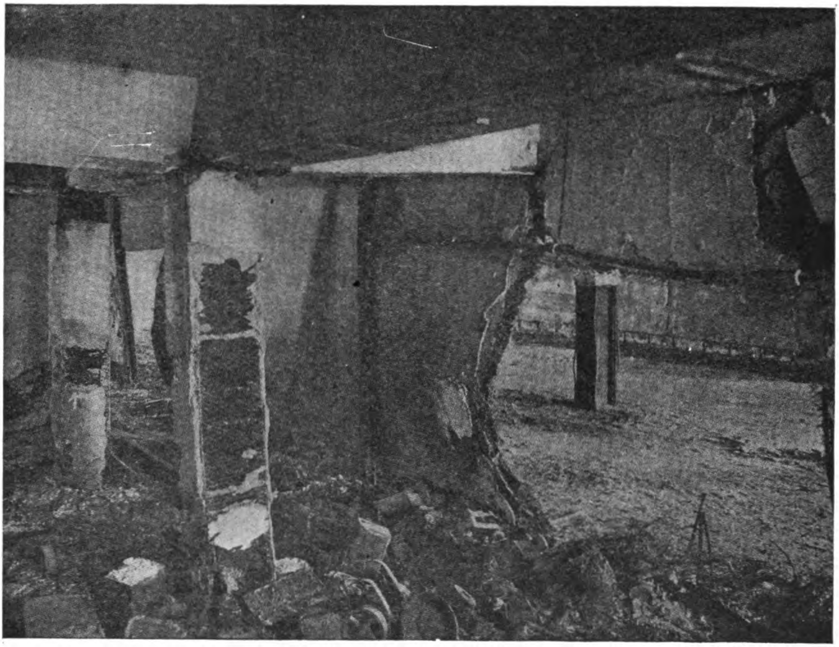


Fig. 36. Wire and Plaster Partition After a Fire

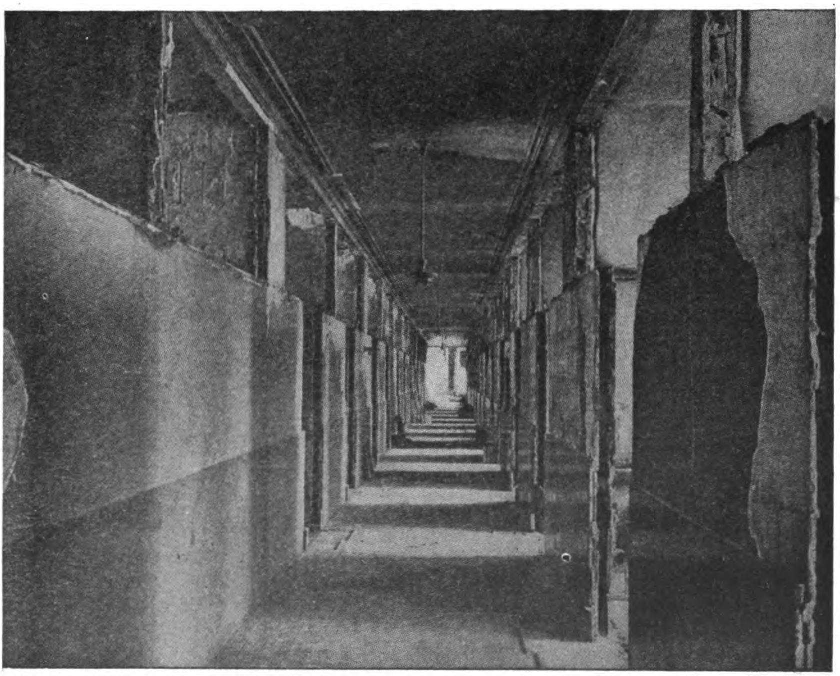


Fig. 37. In San Francisco Long Corridors Had Wooden Sashes and Ordinary Glass Divisions Above the Tile Partitions
All these sashes burned out and allowed fire free scope throughout the building.

the structural steel portion of those buildings; one other designer knew enough to use metallic trimming in his building, and there was still another who, though he designed an obsolete and useless form of general construction, knew enough to protect his building externally with wire glass. Now surely there must be one man there who, in the new city, will give us *one* building embodying *all* those good features; one building that is *really* fireproof and that will stand to point the way—the direction, the means, the manner, of constructing other buildings—after the next great conflagration will have still further accentuated the lessons so forcefully expounded in the greatest of modern conflagrations, the destruction of our western metropolis, San Francisco, once known as "the magnificent" (Not a single building has, thus far, been so built in San Francisco.)

NOTE. To the disturbance that that fire created in our financial centers, the absolute extinction of so great a money value, and the necessity for hurrying so much cash to one (remote) point—the Red Cross Society distributed millions in relief and the Federal and State Governments centered there and scattered many millions more—is attributable in a very great part the general depression of 1907. Our business pendulum was rudely shaken and swayed in all directions and the very delicate clockwork of our financial organism was so disturbed that èven at this late date it still slips a cog once in a while.

Many insurance companies went out of business as a result of the San Francisco disaster, others were badly crippled, and all were made exceedingly nervous, to say the least, but finally adjustments were made and on buildings and contents was paid $138,640,000 to the policy holders.

But little more than that sum has been put into building operations since the fire. That is only a coincidence, however, for, of course, stocks of goods have been purchased, furniture, etc., so that probably nearly twice as great a sum has been put into contents.

Up to July, 1909—our last report—$140,000,000 has been expended in building; 86 first class buildings costing $20,000,000 have been erected, 7,198 alterations and repairs made at $10,000,000, and 1,417 new buildings of Class C—rather inferior construction—costing $45,500,000 have been built, and only 113 of Class B—fairly good construction—while 13,444 *frame* buildings have been permitted—$56,000,000 worth! *Fuel for another conflagration!*

FIRE'S HAVOC

An Economic and Cruel Waste of Life and Property. We note that San Francisco in its upbuilding had again supplied a vast amount of fuel for another conflagration. It would seem that the chief concern of the builders, particularly in this country, and for ages past, has been to supply an adequate amount of fuel, the costliest we could devise, for conflagration and the "occasional" fire to consume. We have done the work well and the results have even surpassed our expectations. The "occasional" fire has become so frequent, indeed there are about three thousand of them a day,

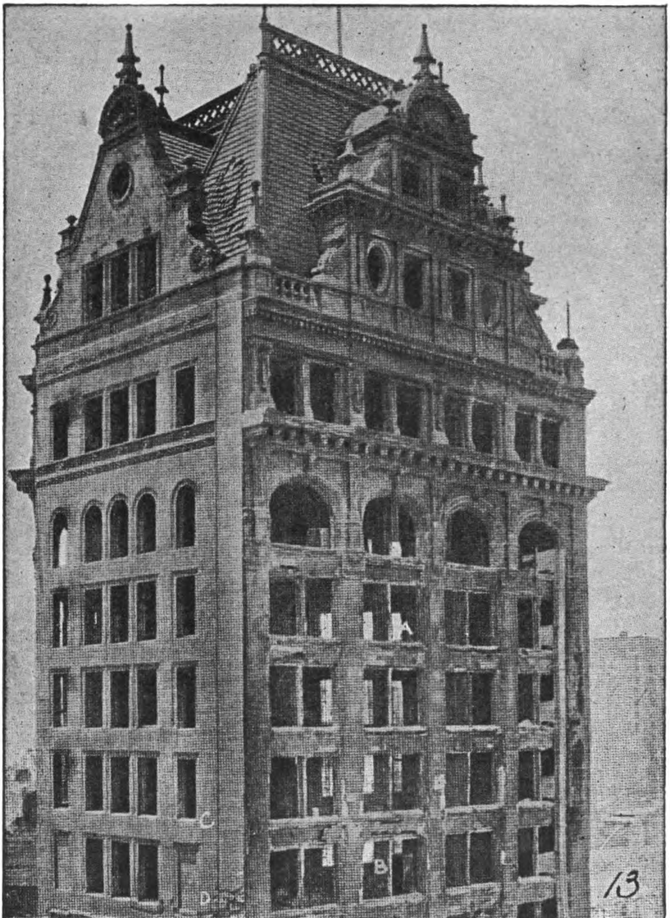


Fig. 38. Note Effect of a Fire Upon the Stone Work of the Upper Parts of a Tall Building

and so destructive—$500,000 and $1,000,000 burnings, a whole block at a time, receive but the most meager, passing notice—that in bulk they total a yearly loss far in excess of any, except one, of the historic conflagrations themselves.

We have reason to be proud of the phenomenal growth of our American cities, the beauty of their buildings, and the vast volume of building construction that is yearly carried on in the process of that growth. But a careful analysis shows us that that great volume of

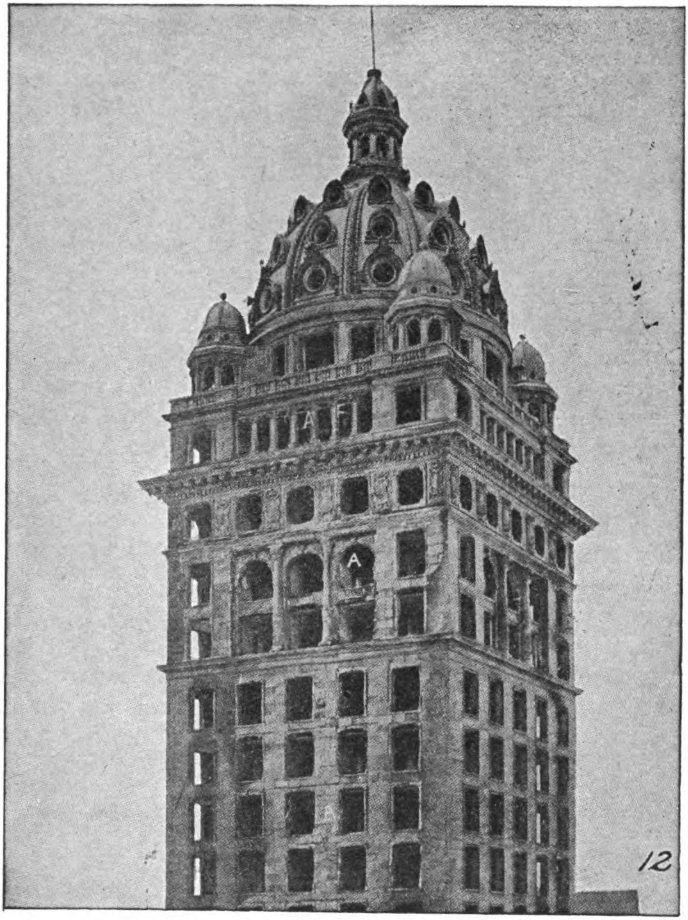


Fig. 39. Note Effect of a Fire Upon the Stone Work of the Upper Parts of a Tall Building

building is not *all* growth but is, to a very great extent indeed, but the replacing of buildings that have been destroyed by fire. And that destruction, a most senseless and cruel waste, has had a proportionate increase, year by year, far in excess of the pro rata of our

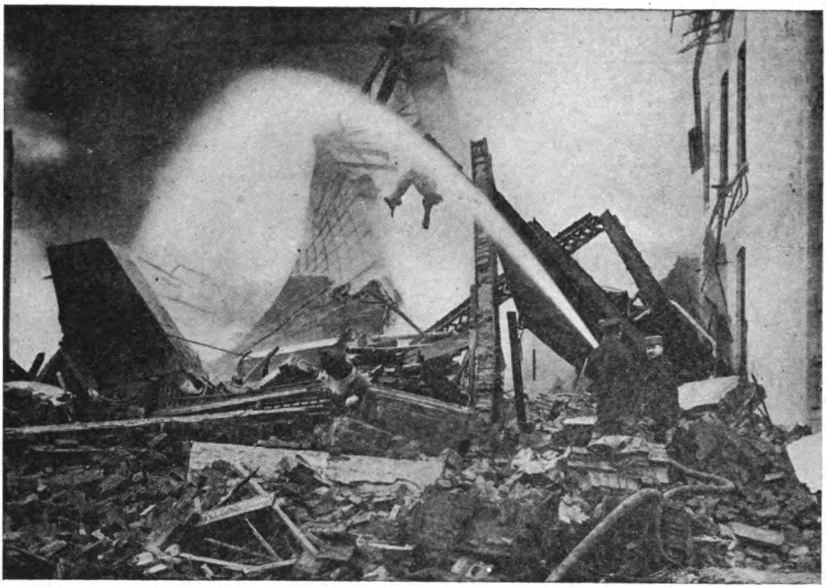


Fig. 40. The Effect of Fire Upon Unprotected Steel Construction

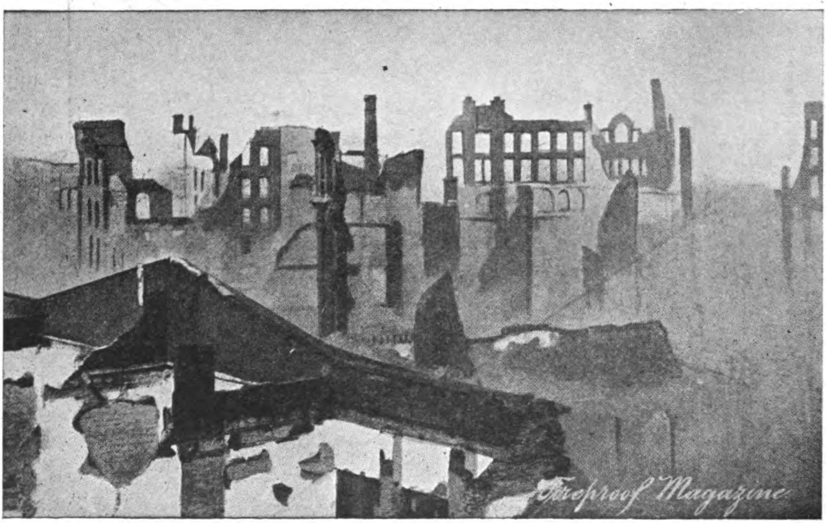


Fig. 41. After the $15,000,000 Fire in Toronto, April 19, 1904

new buildings or indeed of many other details of our rapid growth. In 30 years our population has increased 73 per cent, our fire losses 134 per cent. In this country we deal in big figures and it would almost seem as if we were as proud of our appalling wastes as we are of our mammoth productions. At least one would judge so by the complacency with which we contemplate a drain upon our resources that would be deemed positively intolerable in any other country.

One Year's Fire Losses. Let us see what a year—an average year—has meant in this fire matter. In the forty leading cities, building construction for new buildings and repairs to old ones reach a total value of $478,000,000 in the year, or a grand total in all the cities and towns of $570,000,000. Now then, during the same period we permit to be destroyed by fire, buildings and contents to the value of $218,000,000. Incidentally, the reader will please remember that in most transactions where "losses" occur, those losses resolve themselves generally into transmutations or exchanges. In financial matters where one man loses the other gains; in more scientific operations fuel, for instance, is consumed but produces steam, power. They say that nothing is utterly lost, but we also know in this fire proposition nothing is left but ashes and smoke. It is not an exchange. The destruction of value is absolute, for so far we have exceedingly little use for ashes, and smoke has not yet been turned into anything valuable commercially or scientifically. Add to the value of property destroyed, the cost of maintaining fire departments, fire-fighting apparatus, high water pressure, and city and private efforts at *stopping* fire when it has once started, something like $300,000,000 a year. Then, in a further effort to recoup ourselves after fire has laid waste our property, we have gambled with the insurance companies in a bet that our buildings would burn. During the year we pay those companies in fire-insurance premiums on buildings and contents $316,000,000. They pay us back in adjusted losses $135,000,000, so that the difference between those two sums, $181,000,000, is the amount we pay those companies for the privilege of getting back a little over half of the value of the property we permit to be destroyed by fire. Apply the paid losses of $135,000,000 on the burned value of $218,000,000, and the net loss in property value is $83,000,000, the cost of fire "protection" of all kinds is $300,000,000, and the amount we give the insurance

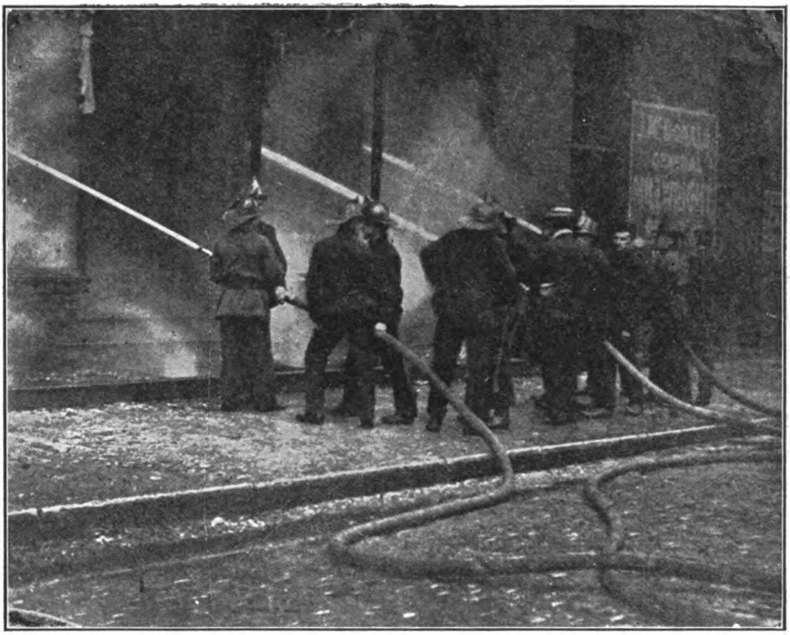


Fig. 42. Damage by Water—$1,000 a Minute While These Three Nozzles Are Being Played Upon the Costly Contents of a Warehouse

Fig. 43. Searching For the Dead After a Fatal Fire

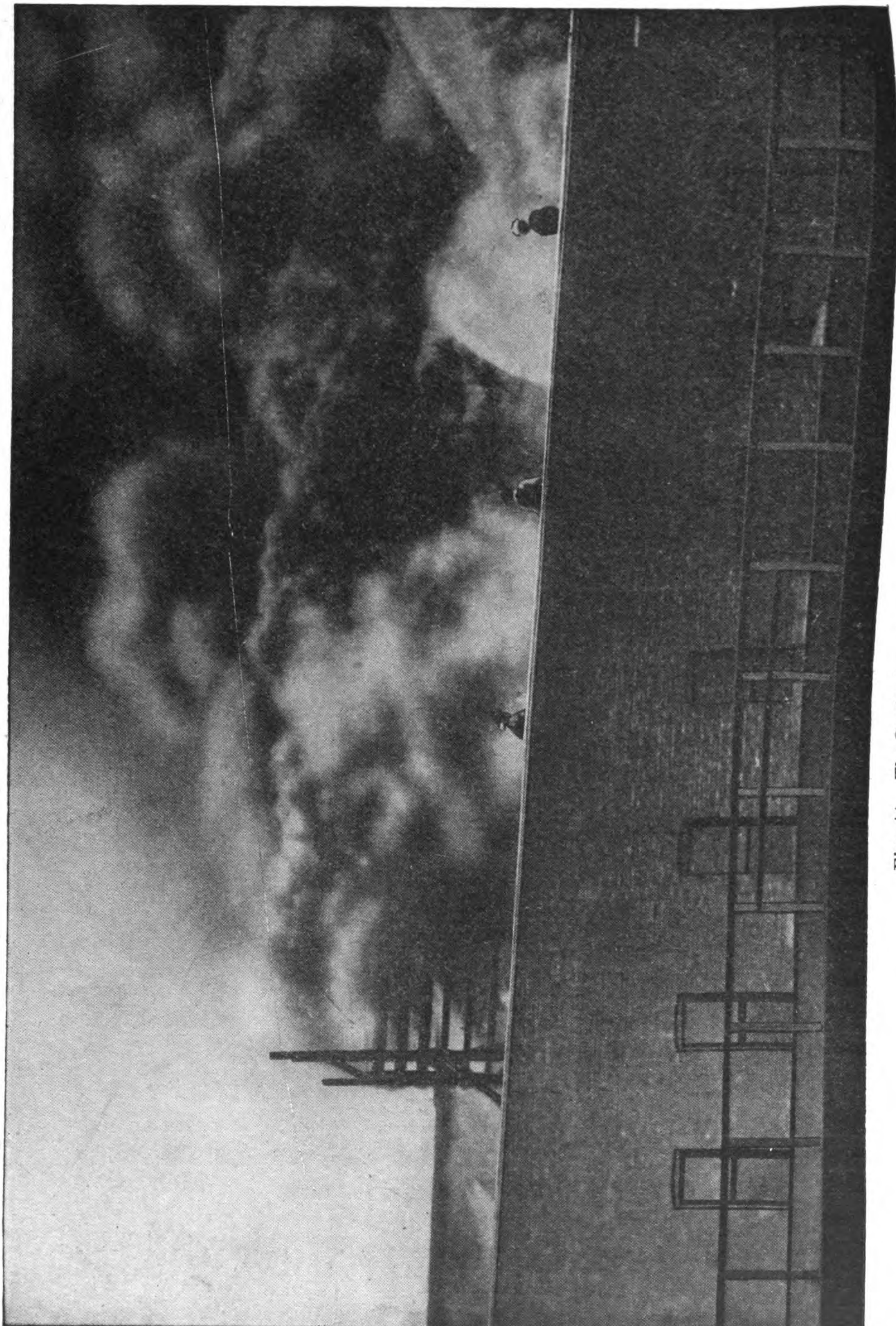


Fig. 44. The Beginning of a Conflagration
A cheaply-constructed building filled with combustible goods, the starting point of a $7,000,000 fire.

TABLE II
Fire Data—Foreign

	Population	Firemen	Fires per Year
Rome	500,000	200	170
Venice	151,000	70	125
Florence	205,000	128	160
Milan	500,000	240	764 (60% false alarms)
Zurich	168,000	18 regular	
		2000 volunteer	72
Strasburg	167,000	210	58
Copenhagen	500,000	280	194
Bordeaux	300,000	204	166

companies to guarantee us some reimbursement for our losses is $181,000,000, so that the total of destroyed values and incidental costs of fire for the year is $564,000,000. Compare this figure that we might call *destruction*, with the new buildings added, $570,000,000, or what we might call *production*, and the result is not one of which we have any reason to be proud.

American vs. Foreign Fire Losses. Eliminating the consideration of the cost of fire-fighting, we have destroyed in property values $4,500,000,000 worth in the past 33 years, and including fire protection the cost has amounted to about $9,000,000,000 in that time. Again eliminating all incidental expense, fire alone has cost us in 1909, $2.72 per capita. Compare that to the fire losses in European countries and you will realize how far behind them we are in fire prevention. In France, Germany, Italy, Switzerland, Austria, and Denmark the general average is a trifle less than 33 cents per capita. In Italy it is as low as 12 cents and in Germany it has never been above 49 cents. In thirty of the principal foreign cities the average was 51 cents, while in 252 of our cities the average was $3.10. In Table II is shown the small personnel of the foreign fire departments and the few fires they have to combat:

The Paris fire department costs but $600,000 a year for maintenance. The city holds 3,000,000 people and the year's fires amount to about $2,000,000. London with 5,000,000 people has a department that costs but $1,500,000 for maintenance and responds to 5,280 alarms.

Now compare with these figures those given in Table III which tell the fire-story in our own country.

TABLE III

Fire Data United States

	Population	Number of Alarms	Percentage of False Al'rms	Property Loss	Cost of Maintenance of Fire Department
New York	5,000,000	15,000	10%	$7,250,000	$7,000,000
Chicago	2,000,000	10,640	25%	4,100,000	3,000,000
St. Louis	600,000	3,292	.07%	1,300,000	1,100,000
Boston	580,000	3,910	10%	3,608,000	1,060,000
Cleveland	400,000	2,500	2%	829,000	679,000
Minneapolis	300,000	1,832	40%	1,060,000	476,000
Washington, D. C.	300,000	960	80%	320,000	604,000

Glasgow's fire loss averages $325,000, Boston's (with a less population) $2,000,000. Berlin with a population of 3,000,000 averages $200,000 and its fire department costs $300,000; compare these figures with Chicago's, a city of two-thirds the population. In Europe they will average .86 fires per 1000 population, while here the average is 4.05.

The equipment of our fire departments is most complete, devices of all kinds and men in abundance, trained athletes, and they need to be all of that and most skilled, for they have enough to do. In New York, for instance, there are 4,264 firemen in 159 companies. They have 55 ladder companies, 4 water towers, 7 fire boats for the river front, and daily use 1,400 horses.

The European city that has a loss of $300,000 a year deems itself sorely tried; with us, a city that has not a loss of a couple of millions feels, it would seem, as if it were being outclassed by its competitors in stupidity—on this subject, at least. Indeed, in this matter of our fire losses, caused by our slovenly mode of building, we have become the laughingstock of all Europe.

NOTE. It is a peculiar coincidence that in the great mass of statistics I have gathered, even from the small towns, the cost of fire and the cost of maintenance of the fire department has run pretty close together.

Analysis of Fire Losses in the United States. In an analysis of the fire loss the fact stands out prominently that much of it is due to fires that extend beyond the limit of the buildings in which they started. It is impossible, from the figures obtained during the inquiry, to give any definite statement as to the amount of the losses due to exposure, but some years ago prominent underwriters estimated that at least 27 per cent of the fire loss comes from fires that extend beyond the buildings in which they originate. These losses are undoubtedly due to the inflammable construction of buildings, for in Europe, where more resisting construction prevails, there is no such loss from this source, fires being more readily confined to the buildings in which they started. It is even more notable that only $68,000,000 of the loss in the United States was on buildings of brick, concrete, stone, and other slow-burning construction material, while double that amount, or about $148,000,000, was on frame buildings. (Our 1909 reports.)

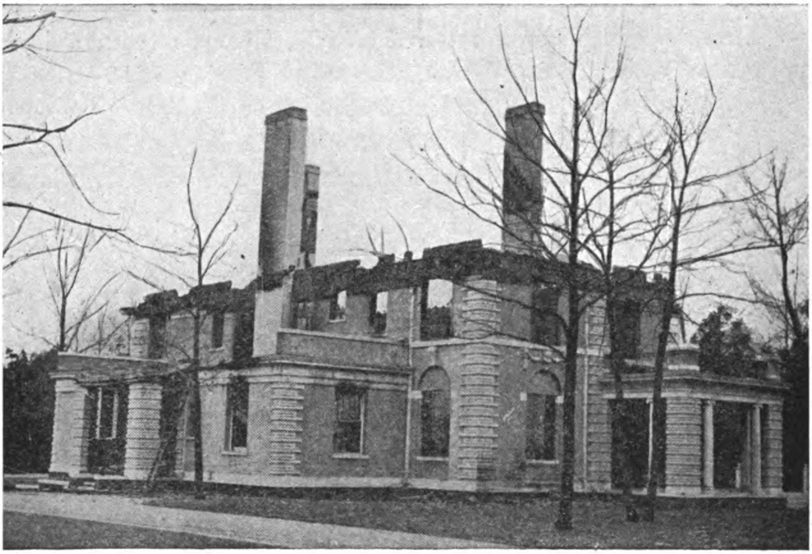


Fig. 45. The Remains of a $500,000 Home
$15,000 taken from the elaboration and put into fireproofing would have made such destruction impossible.

The loss is rather evenly divided between the urban and the rural population, the total loss in the cities and villages amounting to $107,093,283 and in the rural districts to $107,991,426. The total urban population is estimated at 42,160,710 and the rural at 43,162,051. The big losses in the cities and villages are not surprising, for in these are located many buildings filled with millions of dollars' worth of property. These buildings are subject to an additional risk because they adjoin or are near one another. In the rural districts the buildings are widely separated and contain prop-

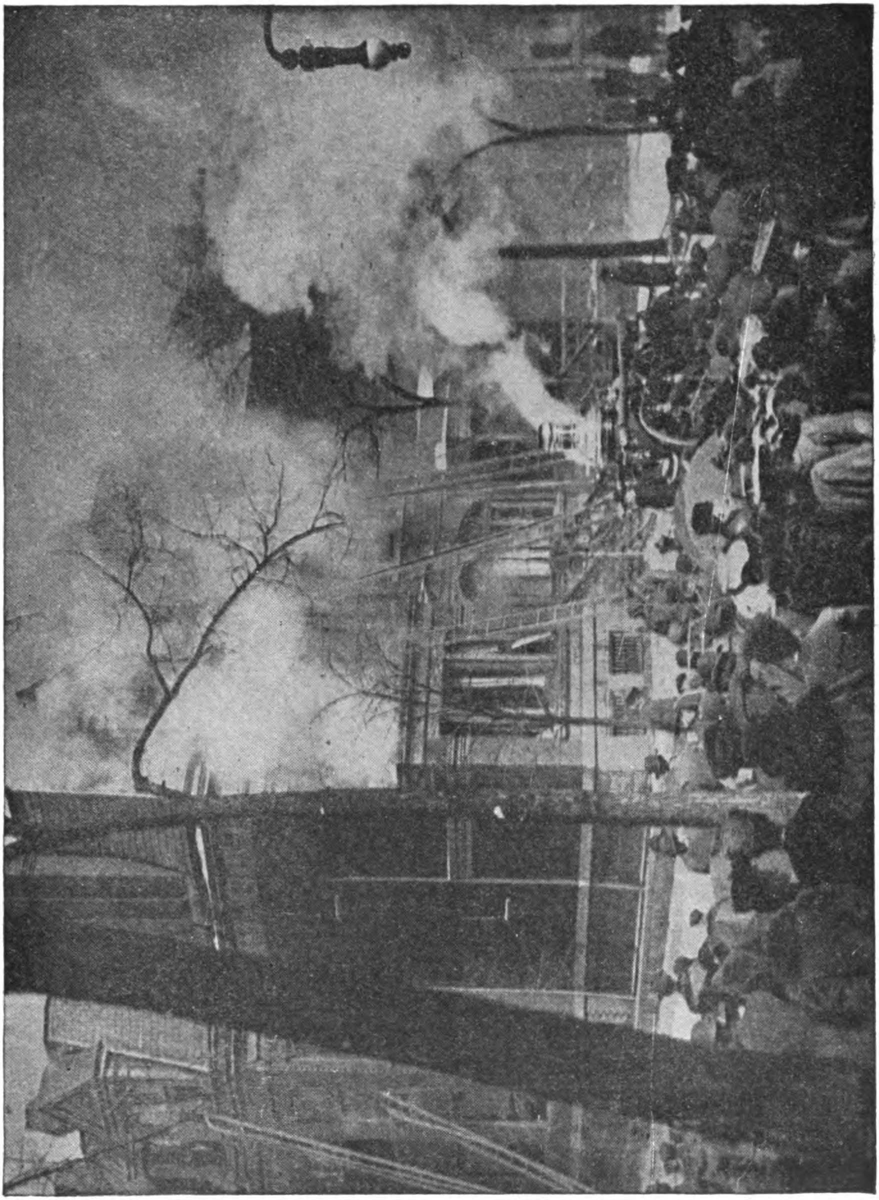


Fig. 46. Seven Lines of Hose Flooding Out a Fire in One of the 84,000 Houses Burned During the Year

erty that does not compare in value with that in the cities, yet the losses are as great in these districts. The only conclusion that can be drawn from this condition is that the remarkable efficiency of the fire departments of the cities prevents a much greater loss than really occurs and that the absence of fire-fighting apparatus in the rural districts permits the loss in fires to be total.

This fact is plainly shown in the total building loss of the country, the fire departments keeping the loss in cities and villages down to $50,173,625, while fires in the rural districts consumed buildings valued at $58,983,269.

The contents loss in the cities and villages was $56,919,658 as against $49,008,157 in the rural districts, which again proves the contention, in spite of the great loss in the rural districts, as it is well known that the value of the property in city buildings is many times greater than that in buildings in rural communities.

The losses on brick, stone, and steel buildings in the cities and villages amounted to $19,816,474 and on contents to $29,092,270; in the rural districts the losses on these buildings were $11,276,213 and on the contents $8,240,310. The much heavier losses in the cities and villages on the brick, stone, and steel buildings are undoubtedly due to the few buildings of this character in the rural districts in comparison to the number in the cities.

The losses on frame buildings in the cities and villages amounted to $30,357,151 and on the contents to $27,827,388; in the farming communities the losses on these buildings reached a total of $47,707,056 and on the contents $40,767,847. This once more tells of the efficiency of the fire departments in coping with the flames in cities and villages and the utter lack of fire protection in the rural districts.

Since the year 1866 the losses by conflagrations in the United States have amounted to $936,551,135, according to tables prepared by the National Board of Fire Underwriters. By "conflagrations" is meant all fires involving a loss of half a million or more dollars. According to the same authority the conflagrations of 1907 cost the United States $18,475,000. The loss by conflagration in 1908 exceeded that of the preceding year by a large sum, one conflagration alone, that at Chelsea, Mass., on April 12 and 13, involving an insurance loss of $8,846,879, as reported by the underwriting companies to the Massachusetts insurance commissioner.

The fact that no other country suffers such enormous conflagration losses has led to a general investigation of the causes by fire underwriters, fire marshals, officials of states and municipalities, and students of economic conditions, and the conclusion reached is that the great loss is due mainly to poor and defective construction of buildings and equipment. The investigation has further disclosed the probability that an *increase* in the number and severity of conflagrations may be expected until there is a decided improvement in methods of construction.

The danger of conflagration is present in every city and village of the United States, and with it the possibility of large loss of life. The most efficient fire department in the country is powerless when once a fire gets under considerable headway in a locality where bad construction prevails.

Losses in Treeless States vs. Losses in Timber States. Another illustration of the influence of frame buildings on the fire loss of the country is suggested by the grouping in Table IV of eleven states which are practically treeless and comparing them with eleven states in which there is still an abundance of timber, the argument being that there will be a greater proportion of frame buildings in the states where lumber is plentiful because of its cheaper price. Table

TABLE IV
Fire Loss in Treeless States

States	Total Population	Total Fire Loss	Loss per Capita
Iowa, Illinois, Oklahoma, Connecticut, Delaware, New Jersey, South Dakota, Rhode Island, Kansas, Nebraska, and North Dakota.	16,785,460	$38,606,558	$2.30

TABLE V
Fire Loss in Timber States

States	Total Population	Total Fire Loss	Loss per Capita
Washington, Louisiana, Texas, Mississippi, Wisconsin, Arkansas, Michigan, Pennsylvania, Minnesota, Oregon, and North Carolina.	23,569,533	$73,895,950	$2.89

V shows that in states where there is a supply of lumber there is an increase per capita loss of 59 cents over the per capita loss of the treeless states.

The remarkable feature is the per capita loss in the South Central states—Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas, namely, $3.66, more than $1 in excess of the per capita loss in any of the other divisions. All of the states in this division except Oklahoma, contain much timber, and therefore many frame buildings. These states also have the handicap of inefficient fire protection as compared with the states of the North and East. The total losses and the loss per capita according to geographic divisions are shown in Table VI.

TABLE VI

Fire Loss per Capita—United States

States	Total Population	Total Fire Loss	Loss per Capita
North Atlantic Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania.	23,779,013	$59,447,532	$2.50
South Atlantic Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.	11,574,988	$25,349,223	2.19
North Central Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas.	29,026,645	$68,793,148	2.37
South Central Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, Oklahoma, Arkansas.	16,368,558	$59,908,992	3.66
Western Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Washington, Oregon, and California.	4,783,557	$12,676,426	2.65

Comparative Figures. Cities of Austria, Belgium, France, Germany, Norway, Russia, Switzerland, and the United Kingdom, with a reported population of 19,913,816, had a loss of but $9,582,340—a per capita of 48 cents. Russia had the highest loss, $3,100,823 in a population of 2,673,427, a per capita loss of $1.16. If the United States had Europe's per capita of 48 cents in a total population estimated by the Census Bureau for 1907 as 85,532,761, the total fire waste in this country for the year would amount to $41,055,725, a saving of natural resources to the extent of $174,028,984. With the maximum per capita loss in Europe $1.16 (in Russia), the fire waste in the United States would amount to $99,218,002, or $116,314,759 less than the actual.

The principal reason for the great difference between the amount of fire waste in the United States and Europe is that there are but few frame buildings in Europe, and practically none in the great cities.

The results obtained indicate that the total annual cost of fires in the United States, if buildings were nearly as fireproof as in Europe, would be $90,000,000, and therefore that the United States is paying annually a preventable tax of more than $366,000,000, or nearly enough to build a Panama Canal each year!

The average annual cost of maintaining fire departments in European cities and in American cities has been noted, from which it appears that the cost in European cities is 20 cents per capita, and in corresponding cities in the United States $1.53 per capita, or seven and one-half times as great. It is reasonable to assume that when building construction in the United States shall have reached a condition similar to that in Europe our annual cost on this item alone may be reduced from more than $25,000,000 to $3,000,000, or to less than one-seventh of the present total. In like manner the annual cost of fire in the United States in comparison with similar cost in Europe, shows that the total per capita cost in this country is nearly five times that in Europe, indicating a possibility of reducing the grand total of this cost from $456,000,000 to $90,000,000, or nearly one-fifth of the present total. It will be noted that the per capita costs in this country and in Europe, which make up these total figures, are almost equally divided between the fire losses and the annual expense of fire protection, and that the ratio of these in the United States and in Europe is nearly the same.

In March, 1907, the Featherstone Street fire occurred in London, involving the loss of $750,000. It created a great stir at the time. The European papers commented that it was one of the biggest fires that ever burned in Europe in 40 years. Upon all of that continent during that period only 48 fires ever equaled or exceeded its cost! Such fires here get scarce a paragraph in our papers.

In June, 1908, there was a fire at Frederichstad, Norway. Twenty-three buildings were destroyed, a loss of $560,000. It set all Europe talking. In all the British Kingdom, last year, there was but one fire of $400,000, one of $300,000, one of $250,000, and only 35 of over $50,000.

Dublin's fires mean a loss of only 24 cents per capita.

The buildings burned in this country in a year, assuming them to be 65 feet wide, would, if placed side by side, line both sides of a street long enough to extend from Chicago to New York.

Of course averages are an unsatisfactory comparison, they can be made to suit any purpose, and are juggled into all sorts of arguments, chiefly to prove political theories, but, after all, they are our only means of comparison. Accordingly we may say that year in and year out our fire losses in and on buildings average $16,130,000 a month, while our building record new buildings and repairs, amount to $45,800,000! The wide divergence in months, however, may be appreciated when we note, for instance, that one month the ratio will be $24,000,000 of fires and $16,000,000 of building and the very next $11,000,000 of fires and $52,000,000 of building. It may be remarked, however, that the heaviest fire months are naturally the winter ones, when heating plants are in full blast and stores and homes, etc., are lighted early in the afternoon. And, of course, the heaviest building months are the summer ones.

Still dealing with averages, the fire loss of the average major city in this country is $1,500,000; in European cities of the same size it is $50,000.

In New York, for example, each fire alarm costs the city, in its pro rata of maintenance, etc., $481.17. Fully 10 per cent of the alarms are false ones. The percentage of loss per fire is heavier in London than in New York, but the fires in the latter city are infinitely more numerous.

During the past year the school and college fires have been fewer in number than the average of other years, only a few over a hundred fires having occurred in such buildings The great loss of life in the Collingwood school fire attracted so much attention that, the country over, better school buildings were demanded and are now in use. We learn slowly, pitifully slowly, and each move must be preceded by an awful lesson. We have had such lessons in theaters and in schools and are mending our ways there; probably the next great lesson will be in a department store fire or an apartment house holocaust. But even though but about one hundred school fires did take place that meant that the lives of twenty-five thousand children were in grave peril during this one year's time. Surely we can give the subject still more attention and yet not be overdoing it.

We average 3 theaters, 3 public halls, 12 churches, 10 schools, 2 hospitals, 2 asylums, 2 colleges, 6 apartment houses, 3 department stores, 2 jails, 26 hotels, 140 flat buildings, and nearly 1600 houses, burned up or partially destroyed every week in the year. In 25 years, 34 capitols, 723 court houses, 1,960 city halls, 163 public libraries, and 1,424 banks have also gone the fire route.

The totals in these figures comprehend fire losses of and on ships and boats plying upon our inland waters, lakes, rivers, etc., but take no account of cargoes in foreign bottoms that may have been destroyed while in our sea-ports. The loss in ships and boats is not great. A boat is generally isolated, not endangered by its neighbors, there is better discipline than in any building, men are trained to watch for fire and to extinguish it in its incipiency and there is always an abundance of water. Serious fires on boats are almost as rare as those in fire department stations.

Depletion of Timber and Iron Supply and Its Remedy. We have ruthlessly destroyed whole forests in getting out the choice timber, and our methods generally, with timber, are criminally extravagant. Then, largely through our own carelessness, fire has helped to complete the destruction. Some years as much as 10,000,000 acres are burned over. Last year was a particularly disastrous year in our forests. Figures can only be wildly approximate but certainly $80,000,000 of "ripe" lumber was burned and fully $90,000,000 of new forest growth.

In the national forests, owing to Forestry Bureau methods and protection, though there were more fires in 1909 than 1908 the loss was not so great. Only 300,000 acres were burned over. Nearly 80 per cent of the fires were extinguished before as much as 5 acres had been damaged, the patrol system is so thorough, in spite of the small appropriation made for that work.

NOTE. In October, 1910, the forests of northern Minnesota were ablaze, one of the worst fires in the history of our forest depletion. Whole towns of considerable size were swept away. Reports show that over 300 lives were sacrificed, and damage to property, towns, and timber to the value of at least $40,000,000. The Duluth Evening Herald sapiently remarks:

How long will Minnesota lie asleep at the gateway of her natural resources, while fire and thievery despoil her heritage?

How many more disastrous forest fires must there be before the state adopts a sound and aggressive policy of safeguarding her own property and that of her people?

How many more times must the settlers in northern Minnesota be scourged from their blazing homes by forest fires caused by neglect before the state takes from its bursting treasury the funds needed to patrol the forests?

How many more lives must be offered up as sacrifices to the state's neglect? How many more frontier villages must be laid waste? How many more thrifty toilers who devote their lives to redeeming the wilderness must be ruined for their pains? How many more winners of the wilderness, the most useful citizens in all the state, must go wandering homeless, unsheltered, hungry, and cold, out of their fire-swept clearings to become subjects of temporary charity?

The state of Minnesota owns vast riches in the north. It is true that much of its timber has gone for a song, and that much of it has been stolen; but much, too, is left, even after the series of forest fires that have swept over the north because the state has not thought it worth while to establish an efficient forest service.

The state owns vast areas of rich land, to which it invites settlers.

Yet the state lets its timber lands go practically unguarded.

It leaves its settlers surrounded by inflammable woods which it does not guard against fire.

It does not build roads over which the settler can get his products to market, and over which he might escape when fire sweeps through the woods.

The state's neglect of its resources is criminal. It is unfair to its own interests, and cruel to those to whom it looks to make its wildernesses blossom.

It is short-sighted folly—worse, it is wicked and wanton waste of lives and property—private as well as public.

So indifferent has the state been to its natural resources that it does not even know what it owns. It knows how many acres belong to it, and something about how much timber there is on its lands. It knows nothing about what part of its possessions are fitted for agriculture, what part should be devoted to reforestation, and what part, being fitted for nothing else, might be turned into game preserves and pleasure grounds.

The state should survey its lands and take an inventory of its possessions. It should patrol its forests, build roads and trails, help the settlers, make it possible for other settlers to come in, and it should change its land laws.

It should create a department to which lands, game and fish, forests —all the state's domain—shall be committed, with fully prescribed powers and duties.

Nothing less than a complete revolution in the state's methods of handling its heritage is required.

The Forest Service and Conservation have their opponents, strange as it may seem. It is always so. Never has anything sensible been advocated but that some "vested interest," some one who benefits by the "insensible" way of doing things, bobs up to oppose it and always, mark you, in the "name of the people." The editor of the Chicago Evening Post touches upon that feature rather nicely in a recent editorial:

The attention of the congressional opponents of the cause of conservation is directed to the devastation in the wake of the fire in the woods of northern Wisconsin. The forests destroyed were held in private ownership, and there was no adequate force of rangers and fire-fighters to guard the property and to check the progress of the flames at a time when checking was possible.

One United States senator, an ardent opponent of forest reserves, has said that forest fires are Nature's cleaning process. Nature is cruel in its kindness. In Wisconsin, in applying its remedy to a disease that neither the senator nor anyone else has yet diagnosed, it destroyed $3,225,000 worth of property and made 300 families homeless.

Fires in the Michigan forests in the late spring and early summer laid waste a great section of country and caused an enormous property loss. If the dry weather continues fire will probably occur in the lower Appalachians and in the Adirondacks. The history of destruction repeats itself year after year in the woodlands which are not under government or state control. The rangers of the United States Forest service by their alertness and energy have kept at a minimum the fire losses in the tracts under their charge

There is a prevailing impression that if forests pass under the control of the state or the general government, the timber supply will be locked up and a famine in the product will result. The legislation to give into government keeping a great area of timber land in the White Mountains and in the Southern Appalachians is not intended to prevent lumbering by private enterprise. The lease system will be authorized and the timber will be taken out under the supervision of experts who will see that waste is prevented, so that the country still may use its wood and have it.

The known supplies of high-grade iron ore in this country, estimated at more than 4,788,000,000 tons, cannot be expected to last beyond the middle of this century unless the present increasing rate of consumption is curtailed. There are in addition about

75,000,000,000 tons of low-grade iron ore which will undoubtedly be used to some extent as the price of iron advances. The supplies of stone, sand, gravel, clay, cement, lime, and slate are practically

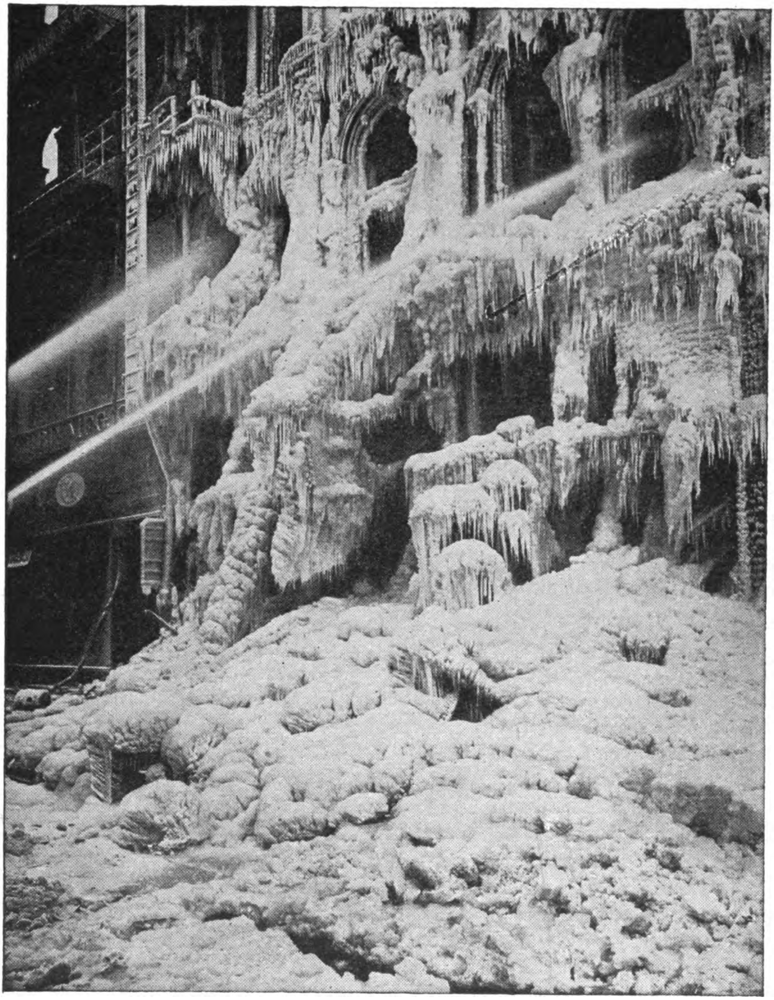


Fig. 47. Where Extremes Meet—Heat and Cold

inexhaustible, and as the supplies of timber and iron are depleted and the prices of these are increased it is evident that the United States must turn to concrete-making materials, clay products, and building stone as substitutes for wood and iron.

Another waste of structural materials that is closely related to the fire loss, is that involved in the use of iron and steel that are placed undergound in city water mains or used in pumping plants to provide a water supply for conflagration protection in excess of that needed for ordinary uses. The investigations reported herein indicate that 22 per cent of the total expenditure on behalf of public water supply is due to additional service necessary for protection against fires of such magnitude that they may spread beyond the building in which they started. There are 2,000,000 tons of metal, valued at $127,000,000 and 350,000 hydrants, valued at nearly $30,000,000, in the systems provided for fighting fires of conflagration dimensions.

The mineral materials available for structural purpose may be divided into two classes: (1) iron, steel, copper, nickel, and their manufactures, the supplies of which are limited and which are themselves subject to destruction through weathering, fire, and other causes; (2) stone, clay products, and cement and concrete manufactures, which are less subject to destructive agencies and the supplies of which are practically inexhaustible.

In building and construction work, the substitution of the materials of the second group for the most commonly used wood and metal manufactures should be encouraged as having an important influence on the preservation of the supplies of the more perishable and scarcer materials. The use of building stone and clay and cement products in this country has been restricted by competition with the much cheaper products and the more easily fabricated and available metal products. Improved methods of preparing the raw materials for use in building construction are, however, rapidly diminishing the difference in cost, and careful investigations as to their structural qualities and the more suitable structural forms would have an important influence in further reducing this difference in cost and *in enlarging the use* of the more permanent materials.

Fireproof Construction the Only Adequate Protection. Surely we have had figures enough to clearly establish and to firmly impress even the layman that fire can be said literally "to be eating at the very vitals" of our economic structure. It is one of the big factors in the wanton destruction of life, some years as many as 6,000 lives having been sacrificed, while last year the record showed a loss of

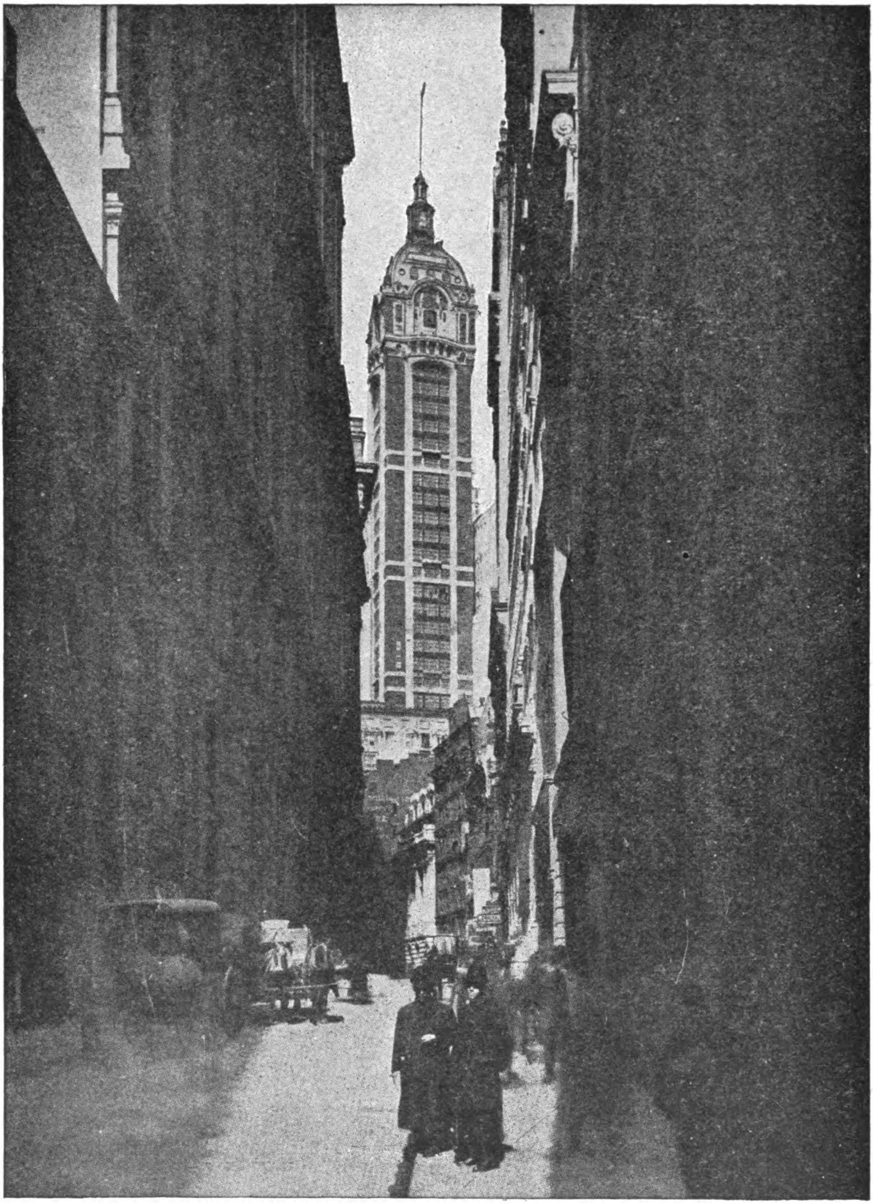


Fig. 48. The Singer Tower Building

This is seen through the Narrow Canyon of one of its neighboring streets. Think of the havoc fire could play in the very tall buildings both sides of these dismally narrow streets, unless all the windows are protected. Probably not over half a dozen buildings out of many hundreds are so protected, yet nearly all of them are expensively "fire-proofed" as far as the structures are concerned, though the finish is almost invariably of expensive wood and the exteriors are often of granite and marble. These buildings cost hundreds of millions; house thousands of humans, and contents to the value of other hundreds of millions, and offer them *absolutely* **no protection from fire. Malignant, criminal, atrocious ignorance or carelessness.**

1,449 lives and 6,000 people seriously injured. It ranks but little below our murderous railways that in a recent span of but three months killed 149 people and maimed 16,937! And yet all of us live and do business in buildings where we are constantly exposed to danger by fire, for there are very, very few buildings where fire is not only possible but very probable. However, let us set aside such broad terms and base our calculations solely upon the actual number of fires that do occur, and we find that fully 36,000 lives are daily in *actual* peril—that is, daily this many people get out of burning buildings, are carried out by firemen, *or otherwise rescued* just in time to escape death. Many causes have contributed to this deplorable condition. One is that our people are naturally reckless and careless and build as they do much else, merely for the moment. Then, too, until very recently our lumber supply has seemed inexhaustible and it was the material with which buildings could be erected with greatest rapidity and least initial cost. The pioneer could not be expected to haul brick and steel into the wilderness when he had trees all around him from which he could fashion his rude habitation. Pioneer settlements grew into villages and the villages into cities and the habit of building of wood stuck to them. Why, even last year, with the price of lumber 100 per cent higher than it was ten years ago and with incombustible materials available everywhere and at low cost, we still built 61 per cent of the year's construction of wood! In the older communities, in Europe, they have got well over their pioneerdom and lumber has never been so plentiful as with us, and the authorities have had more forethought and realized the necessity of better construction so that the general average of the buildings in cities, towns, and villages is infinitely less inflammable than is the average here. But from that it must not be deduced that the science of building is carried to greater perfection there than here. That seems an anomalous condition but a fact it is, nevertheless, that our architects and engineers know a great deal more about fireproof construction and practice it to a far higher degree of perfection than do the architects and engineers of Europe. They really have nothing to compare with our superior buildings. Take, for instance, the Singer Tower in New York, and, regardless of its height, there is nothing in Europe to compare with it in the way of fire-resisting qualities. The trouble with us is that there are so few of those buildings. We have something like 12,000,000 structures in the country, but of that vast number there are but 8,000 in which much effort has been made at fire-prevention! It is our average construction that is so poor and that makes sucha bad showing as compared with Europe. You can readily see that in a city composed of buildings which, although not fireproof, are comparatively incombustible, the fire hazard is much less than it is in a city of fire-traps with a few perfect buildings scattered here and there. And, too, in order to resist fire those fireproof buildings have to be superlatively perfect, because there is so much fuel all around them that a fire attack against them is vigorous in the extreme. In European cities the big and important buildings need not be so perfectly constructed because the danger of fire from within is always the minimum and the danger of fire from without is not very great on account of the superior *general* quality of construction. There, it is seldom that a fire gets beyond the building in which it originates; the owner is responsible for the damage to his neighbor's property if it does; here, in spite of our splendid fire departments—and there are none superior to them, for none have the practice and experience they have—fires frequently extend to neighboring buildings, entire blocks, and indeed whole sections of cities.

Municipalities, states, and even the country at large, are beginning to realize the gravity of this fire-waste and that something drastic has to be done toward fire-protection. The great trouble is that whatever we do now can simply be an abstaining from adding fresh fuel to burn, because we have received such a heritage of combustible buildings that it will be yet many years before those old fire-traps will have been destroyed or torn down to be replaced with better buildings. But a beginning has to be made sometime (for the percentage or pro rata of fire destruction is ever increasing more rapidly than the increase in new buildings or the percentage of efficiency of our fire departments) and most cities of our country have so re-vamped their building-regulations that at least within certain districts nothing of an inflammable nature may now be erected. But that is not enough, because immediately outside of those districts we are permitting fire-trap construction that, in turn, will be the inheritance of our successors and will be in congested districts and will prove almost insuperable barriers to real progress. The thing to do is to absolutely prohibit inflammable construction, the use of wood, in the structural parts of buildings erected *anywhere* within the jurisdiction of the city, and the state should not be far behind in restricting and safeguarding the buildings in the rural districts.

CAUSES OF FIRE

Primary Causes. Specialists, insurance experts, and fire departments zealously seek out and tabulate the direct causes of fire, attributing it to this, that, and the other thing. Simmered right down to the final analysis we shall find, however, that the listed "causes" are but the intervening or secondary agencies and that 999 fires out of 1,000 are very directly due to *carelessness* or *inexcusable ignorance.*

These primary causes are responsible for the terrific loss of life and limb and property in this country. We are the most careless people on earth. We permit a looseness of conditions, a recklessness of method, or a method of recklessness which would not be tolerated in Great Britain or Germany or France. This laxity runs on our railroads, pervades our coal mines, meanders in our mills, asserts itself in the slovenliness of our cities and our vacant lots, and is traced directly to our homes along the icy sidewalks to our front doors and the doors of our churches and public institutions. The average American cares no more about the conditions outside the walls of his home than he cares about the conditions on the most distant planet. He is indifferent and unashamed.

And yet it is small wonder that men recklessly throw cigarette stumps about and do other foolish things that cause so many of our fires, for they are brought up with a total disregard for the possibilities of such recklessness. As little children they are not cautioned enough against playing with matches—they are given toy steam engines and that means lighting fires to operate them; the great Fourth of July they are given numerous dollars to spend upon the most fire producing agency known and are, that day, openly aided and abetted in playing with fires by their fond papas. Result: where there are 40 fires a day generally, in that same section on the Fourth of July there are 130. Incidentally those same crackers and fireworks result in 5,307 persons being killed, blinded, maimed, or otherwise injured each year. Enthusiastic, unreasoning, and disinterested patriotism surely!

Secondary Causes. Now as to secondary causes, suppose that an earthquake shakes part of a building down and fire ensues, the damage may be attributed to *earthquake.* But if the building had been properly built it would not have been shaken down and if the materials used had not been inflammable there would have been very little or no fire anyway. Carelessness or ignorance prompted that mode of building and to either or both should be charged the fire. Another secondary cause is the *defective flue.* If such defective construction is not due to carelessness or ignorance what can you attribute it to? And so it is with the entire list of causes. After the defective chimneys, flues, and fireplaces, and heating and lighting apparatus, come matches, sparks, and explosions followed by incendiarism and lightning; however, nearly one-fourth of all the fires are labeled "unknown causes."

One authority has carefully tabulated the fires in this country for twenty-one years. He finds that crime or mischief fires numbered 31,000 out of the total of 369,298, a matter of $210,856,542 worth. Incendiarism was responsible for $199,755,000; cigarettes and what even the layman calls *carelessness* caused $266,040,000; burglars, tramps, and lunatics $8,500,000; children and matches $1,000,000. It is notable that cigarettes alone did more mischief than electric wires, lightning, cyclones, or earthquakes (barring San Francisco) in the same space of time. Ashes stored in combustible vessels, woodwork too near heating apparatus, the handling of gasoline, and the accumulation of combustible rubbish in hidden corners are also prolific causes of fire.

In Europe perhaps closer check is kept on alleged fire *causes* than here. Of 79,931 fires lately reported 4,292 were attributed to unknown causes; 10,884 to "exposure" (fire originating elsewhere and carried to the premises by sparks, open windows, etc.); 15,558 to carelessness (cigarettes, lighted matches thrown in waste baskets etc.); and 16,886 to faulty heating methods or appliances.

Incendiarism seems to be more rampant in Europe than it is here, or else our incendiaries do their work more skilfully. Howbeit, a greater number of incendiaries, pro rata of fires, are apprehended there than here. Just recently a very "respected" merchant of London was caught setting fire to his place and finally confessed to having started six other fires in the year and several before that.

In a report covering a long period an English commissioner gives 50 per cent as the number of fires that were suspicious.

Rather closely akin to incendiarism is the spirit we so often find of not only carelessness but absolutely criminal contributory neglect. Only a few days ago I was remonstrating with a storekeeper for having a gas light so directly under and near a wooden ceiling that it is only a question of time when the ceiling will be ignited. And neither had he any hose nor buckets nor other provisions to immediately extinguish an incipient fire. He complacently assured me he would incur no expense in changing the lights nor would he bother with any buckets. His stock was fully insured, the building didn't belong to him, business wasn't very good anyway, and his stock was cumbered up with old stuff, a fire didn't scare him, and if one started he'd make it his business to take his hat and walk out, and the fire department could busy itself extinguishing it. And that is exactly the spirit of a very large number of our people, men we call absolutely honest but, to my mind, but a step removed from actual incendiaries, criminals at heart.

New Inventions Bring New Hazards. The development of great inventions are not without their drawbacks, no great gain being secured without some measure of offset. This largely manifests itself in the matter of fire hazards; new ones constantly presenting themselves to plague fire underwriters, city fire departments, and those directly interested in fire prevention. This was made manifest in the deliberations of the executive committees of the National Fire Prevention Bureau and consulting engineers of the National Board of Fire Underwriters, which recently held meetings in New York.

One matter that attracted much attention at both meetings and consumed considerable time, was that of the fire hazard of the film exchange. Nothing, not even automobiles, has ever developed in this country in a manner to compare with the moving picture show, which has become firmly established, not only in all our cities, but in the smaller towns and villages. To such an extent has this industry developed that it has added greatly to fire risks. A number of disastrous fires which recently originated in film exchanges led the fire prevention experts to consider the dangers of the business and the methods of preventing them. The film exchanges keep constantly in stock a large supply of the rolls of motion photographs, which are rented to picture shows. The films are of cellulose, which is not only of itself highly inflammable, but even at a normal temperature gives off a vapor which when mixed with air is highly explosive. The attention of the fire prevention experts was given chiefly to methods of ventilating the storage rooms so that the explosive vapors would be carried off as fast as they were formed and thus be prevented from massing in dangerous quantities.

Another fire hazard that has quite recently developed depends somewhat curiously upon the installation of apparatus for the extinction of fires, incipient blazes particularly. The new risk which was much discussed at the recent meetings arises from the insecure manner in which gravity sprinkling tanks are supported on the roofs of sprinkler protected buildings. The first disaster due to this cause occurred in St. Louis, where a match factory was set on fire by the collapse of a sprinkler tank on the roof, and this was almost immediately followed by another at Montreal in which the collapse of such a tank started a fire in a printing house. A third fire resulted from the same cause a little later in Chicago. In each of these cases the fire was caused by the rusting of the iron supports of the water tank. The fire prevention experts developed plans for barring from the support of tanks all material subject to disintegration by the action of the weather.

Other fire hazards which have developed with the development of modern inventions were under consideration at the meeting; the oxy-acetylene blow-pipe process, by which structural steel is cut by melting along a narrow line as easily as wood is sawed, is a process used in welding operations. The high heat developed makes it necessary to handle the process carefully, a number of fires having recently originated from the explosion of tanks containing the gases whose mixture and ignition produce the heat. Another hazard is the portable gasoline engine, used by farmers in the harvest fields for operating threshers and harvesters.

National Building Code. The matter that attracted the greatest attention at both of these meetings was the problem of securing uniformity in building methods by determining the best practice and strongly recommending it in all sections of the country. At present a wide difference of opinion exsists as to various operations, notably electrical wiring, the location of stoves, and the construction of foundations for furnaces.

All these points come properly under the head of municipal building regulations. Pretty nearly every city in the land—in the world—indeed, is at work upon such regulations or amendments. Local talent is usually called upon, a commission organized to write a building code—a commission composed of an architect, an engineer, a doctor, a lawyer, the usual "prominent citizen," probably a candlestick-maker. In many cases some of these men have never before even seen a building code; in some cases they have sense enough to adopt almost *in toto* the code of some other city. Frequently rival building interests clash. Less than a year ago there was a serious rumpus in New York over a proposed building code, contending factions got into a row and the thing grew into a great political issue. As may be surmised a grand hodge-podge of regulations was the result. It is eminently desirable that those laws be clear, brief—dealing with essentials only—and uniform in cities of the same region. Better still a uniform code for the entire country is desirable.

The underwriters have studied and they advise such a code but it is rather cumbersome and involved. The Society of Building Commissioners to which the Building Commissioners or Inspectors of nearly every city here and in most important cities of Europe belong, and of which society I have the honor of being the Executive Officer, has long advocated a uniform code and lately we have actually begun to write it, a code that, through the efforts of our members, the chiefs of the building departments of all those cities, we hope to have adopted by every city within the next few years. For a long time it has been my ambition to have not only the cities but the states adopt a uniform building code. Remember that the village of today is the city of tomorrow, outlying districts are constantly being absorbed into cities and with their inheritance of inferior building and fire danger. The state should regulate the minimum of excellence allowable in any character or class of building, city or country, below which standard nothing should be permitted. Then each city should, according to its class and size, add to those initial requirements. But the states should supervise the whole question of fire.

Little by little they are coming around to the idea. Massachusetts was the first to establish the office of State Fire Marshal; then Maine, Maryland, Minnesota, and Missouri; and now nearly all the states are creating such an office. The Fire Marshal tabulates the fire losses, does what he can to lessen them, has the power of arrest in cases of infraction of certain laws, etc., etc., and is paid generally out of a tax upon insurance companies doing business in that state. His office is not yet an important one and his duties and the restrictions he can impose to prevent fire are pitifully few, but the establishing of the office is a step in the right direction and before long we hope to make his functions important, valuable to the State, and of immense benefit in the protection of life and property against fire.

FIRE EXTINCTION

Much as with the "causes" of fire, many agencies are wrongly supposed to be preventive when they are but more or less effective modes of extinguishing fire when it *has* developed. Water, automatic-sprinklers, chemical fire extinguishers, and even fire insurance are popularly, though erroneously, put under the head of "prevention."

In considering what really is fire-extinguishing, water is the forefront, the chief actor upon the stage. On board ship they now have a machine that generates or extracts the gases from the smoke poured out of the funnels and forces these gases into the hold or any compartment of the ship until any fire there is absolutely choked, smothered out—an effective and cheap mode of putting out fires. However, this method cannot or has not yet been used on land, for but few portions of a building could ever be made air-tight enough to prevent such gases from being immediately dissipated.

Many chemical engines and hand extinguishers, grenades, and what not, are used, and effectively, upon insignificant blazes. These contrivances are generally air-tight receptacles, tubes, corked bottles, etc., in which, as soon as certain chemicals are upset into the water of those appliances, a gas is generated that expels the liquid with great force against the object on fire. As this liquid is charged with salt, alum, or ammonia, a coating substance is formed which does really more good, over a small area, than much water.

Live steam is also effectively used, but, over and above all else, water is our great fire extinguisher. The idea is to drown out a fire. It is exactly what our greatest grandfathers did, only we apply the water a little more scientifically than they did. They used buckets, hand pumps, and such primitive methods while we have engines and throw tons of water where the ancients applied a bucketful. We indulge in wonderful steam engines, athletic firemen, scientific chiefs, speedy horses, and fast automobiles to get to the scene of the fire, and endow the whole performance with much eclat, precision, and such accompaniments, but it is still, as it was a hundred or a thousand years ago, merely a matter of putting on water enough to quench the fire. And oftentimes the zest of the firemen is such that infinitely more damage is done by the water applied than by the fire it puts out.

The automatic sprinkler has been a wonderful help in that drowning-out process. The system, which is carefully explained in all its details in Fire Insurance Inspection Part III, is briefly a series of lines of water pipe along the ceiling of a building, these pipes being provided with heads every few feet and a carefully constructed valve to operate and control the water system in case of a fire. The sprinkler heads are closed by spring valves which remain shut by virtue of fusible metal seals. When a certain degree of heat is reached in the neighborhood of the "head," the fusible metal melts, releases the spring valve, and opens the heads. The lowering of the pressure in the pipe system due to the opening of the head or heads sounds an alarm and the fire is investigated at once and the water turned off. In the early days of the sprinkler system it was not always an unmixed blessing, for sometimes it failed to close or was opened, and a "near" flood ensued. I well remember one case, several years ago. I had gotten a grain elevator company to install such a system, then brand new, in one of their big elevators. The third night of its "protective service" something went wrong with three nozzles. There was no fire, simply an accidental opening. At any rate they ran all night and ruined 300,000 bushels of wheat, flooding the bins! Naturally I was not blessed by that company, though that experience led me to the invention of the bin-cover and scupper drains that were at once put in all other elevators and made impossible the recurrence of such an accident in those buildings. The natural improvement in the mechanical appliances in connection with the sprinkler systems and the introduction of "dry pipe" systems where the pipes might freeze have reduced accidental "floods" to a very small number. The installations are becoming the rule rather than the exception, and the prompt execution of the sprinkler heads by which so many fires are put out in their incipiency makes the automatic sprinkler the most valuable and effective adjunct to fire fighting that can be placed in a building.

We have noticed what fire departments and the ordinary water service cost us in maintenance. But there are extraordinary expenses not comprehended in those totals. For instance, New York has installed a special fire service-water-system in the down town district that cost $7,000,000 or $8,000,000. With that it can concentrate, by combining pumps, something like 50,000 gallons of water from the river per minute at any one point in that district. And Chicago is spending $6,000,000 for a similar fire service that is being installed for the special protection of some 1,863 buildings constituting the "congested district."

THE INSURANCE IDEA

The strangest misapprehension of all is the ridiculous idea some people have that in some occult way insurance is actual protection. There are thousands of people today who imagine that the moment an insurance policy is in force on their property, its safety is assured; and so keen this is superstition—though many will not admit it—that it results in a well-defined feeling of impending disaster when the policy has expired.

Fire Insurance has been reduced to an exact science; it is the real application of the law of averages. About it have grown many rules and forms; it is one of the great established businesses of the day, and a most important one. Indeed without it, as our modern affairs are managed, thousands of transactions now common would be impossible and probably the wheels of progress would be badly blocked. The science of insurance in its applications to the determination of rates, valuations, etc., will be discussed later; now we shall consider the history of insurance, some of the abuses that have resulted from the habit—in itself good—and the application of Fire

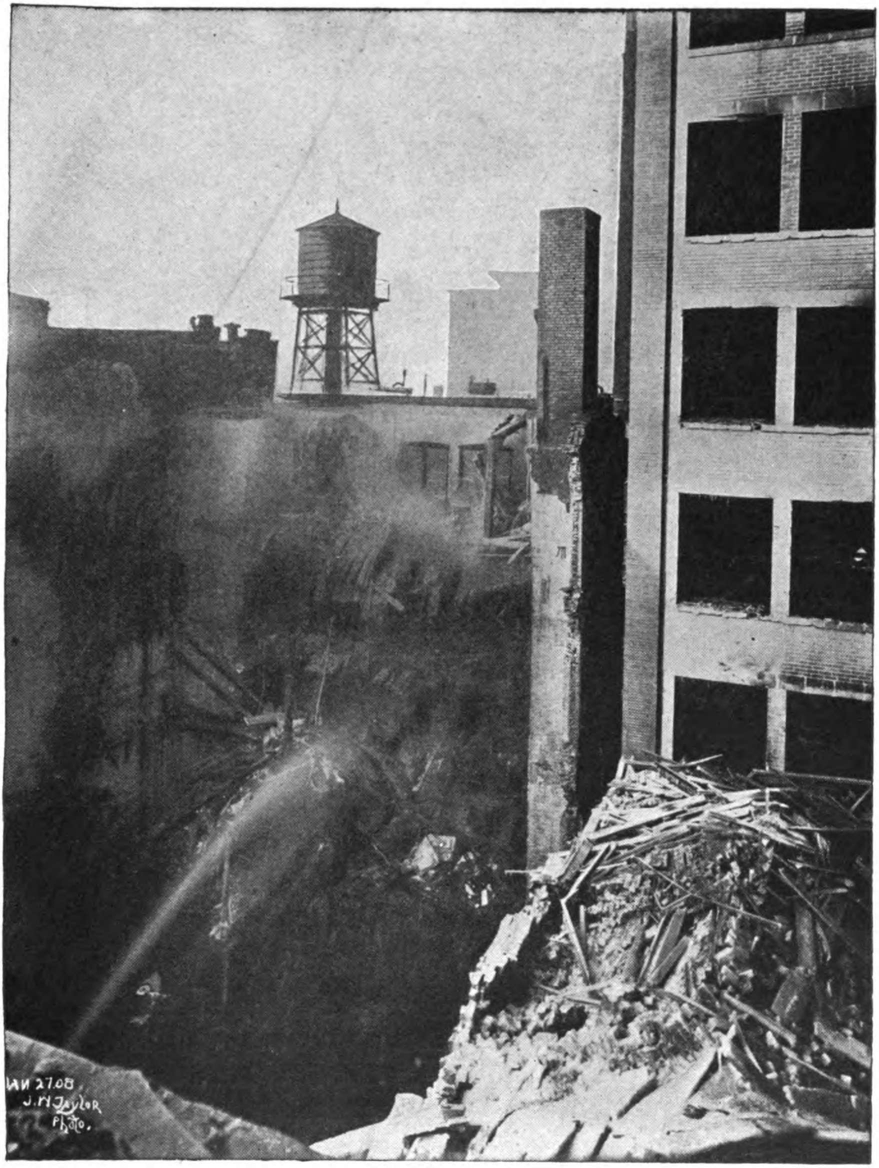


**Fig. 49. Alleged "Slow-Burning" Construction
This fire lasted 45 minutes.**

Insurance from the Fire Prevention point of view. These opinions may be looked upon as radical by the professional insurance man, but they are the result of long familiarity with fire and the study, at short range, of all the phases of the situation.

Fig. 50. Standard Oil Tanks Ablaze—A Dangerous Risk to Handle

Traces of insurance are found even in the times of the Pharaohs and in early Greek and Roman history. It was a natural sequence to trade and barter. The Emperor Claudius, in an endeavor to encourage the importation of corn, guaranteed to make good any loss the importers might suffer, and therefore he may be looked upon as one of our early and most beneficent insurance men.

Many of the old Anglo-Saxon guilds or unions arranged a species of fraternal insurance. They clubbed together in weekly assessments from which any of the number suffering from fire, robbery, or flood was recouped at least part of his loss. Insurance was the subject of some laws and ordinances passed in Barcelona as early as 1435 and we find records of its being an established, legitimate association-function in England, in Italy, and in Holland about that time. In England there was a full-fledged insurance company in business in 1696 and, by the way, one of the existing English companies is its direct lineal descendant.

Fire Insurance has ever been a most important feature of insurance—indeed it antedates by many years Life Insurance and the infinite variations of the same theme. The English companies probably take no greater, if as great, risks than do ours, but they diversify more. There are old and financially sound companies in England with whom you may take a chance at anything. They have so long and varied an experience, and their tables of possibilities and averages are so exhaustive and carefully prepared, that you can go to them and pay a certain premium and get yourself paid for a whole wheat crop if it rains before your harvest; if you are a merchant and intend laying in a huge stock of goods in anticipation of the festivities attending the crowning of a new king they will assure you against that king's dying and ruining the sale of these goods; in fact anything that you can think of they will take a chance at with you.

In this country you are somewhat more restricted as to the chances a company can take and still be within the pale of the law. Primarily established as a wise and beneficent safeguard against possible loss attending an accident, a means by which a community contributed a sum of insignificant units that would recoup the individual at least in part for the loss he might suffer by fire, insurance has grown to be a gamble of vast proportions and far-reaching influence, and our great Fire Insurance companies, by refusing to make sufficiently discriminating rates against poor building construction, have enormously increased the chances of fire. To follow the growth of the abuse of insurance might be interesting but would be something aside from our purpose, so let us simply look at it as it is today.

Only a few years ago the companies figured up scientifically their ratio of losses versus premiums, but paid only scant attention as to how buildings were built and how cities were managed from the view-point of fire prevention. Today they have broadened out to the point where their engineers are among the most skilful in the country and know exactly how buildings *should* be constructed. The underwriters issue very learned treatises upon model construction and build their own buildings well-nigh perfect, but that accomplishes comparatively little, because they do not make their rates in consonance with their ideas of sound construction. There is not enough difference between the rates on a superior building and those on a very ordinary one to make people believe that there is any advantage in building properly.

To put it frankly, although the companies fear and guard against conflagration, yet in the very nature of things it is human for them not to look askance at very frequent small and some moderately large fires. They all accelerate and improve business. The losses are so distributed by their clearing-house methods that no one company suffers much even from a big fire and the oftener fires—not conflagrations—occur, the more certain people are to *insure* and the larger will be the policies written and, consequently, the larger will be the premiums. Ergo, the more fires the better; the other man's misfortune is their gain.

A city composed entirely of fireproof buildings and in which only some small part of the contents could possibly burn, would offer poor opportunities for the insurance agent. Is it natural to expect men who make their daily bread, and considerable gain, out of the insurance business to do very much toward the realization of such an ideal city; do you expect them to show more than half-hearted enthusiasm toward fireproof construction?

And yet, the travesty of it all! It is to the insurance expert that the laymen, our city authorities, our architects, and our engineers go when seeking information about how building should be done, what laws to establish, etc., and those same insurance experts can hardly be expected to advise much more stringent regulations than the insurance companies and their experts exact.

The power wielded by these companies is astounding, and they use it autocratically. To protect themselves against conflagration losses they may deem it wise for such a city to install additional fire stations or more machines or better equipment or increased water service. The people of those cities may have begged for just such things for years and their appeals were unheeded, but let the underwriters make these same demands, and the authorities hasten to comply. The fact is, the companies are well organized and they stand together; and consequently any ruling made by the national board or by the local board is adhered to and sustained by all the companies. Those united companies constitute a very real and potent power. That they generally use it with discretion and with little abuse is greatly to their credit, although we must not lose sight of the fact that it is to their former laxity and to their willingness to insure poor risks earlier in the game that must be attributed, in great part, the conditions that now compel them, in self-protection, to demand the additional safeguards they are insisting upon.

The whole problem becomes quite clear to us if we but view it rationally and divest it of the sentiment we usually attribute to insurance and realize that it is merely a cold business proposition. The companies are not interested in a city's welfare nor in that of its citizens. It exists for the sole purpose of making money for its members, salaries for its officers, profit for its stockholders. When a building was erected alone in the center of a block it was not particularly exposed to external fire. It was most natural, therefore, that the companies should make a low rate upon it even though it was built of inferior construction. Then when another such building was erected upon the same block, although the danger to both was increased, still the companies could take a pretty stiff chance at the old rate, which was sufficiently "attractive" to convince a third man that that sort of construction was perfectly safe and all that was needed. He, too, built on this block; and later another. The block began to be crowded, and the companies, realizing that it was no longer a case of the possibility of having to pay for one building in that block but that if fire started in one the whole lot of them were more than apt to be destroyed, naturally raised their rates upon them all. If another man wanted to build there he had to do it much better than the others, his rate upon anything else than almost fireproof was prohibitive, the companies didn't want to assume any more risks there, nor did they want anything to further jeopardize the risks already written. Then they turned their attention to "protection." The city was notified it would have to put in a fire station near that block, more hydrants, and greater pressure. Not that the companies gave a thought of the city's safety or the lives in it, but they wanted *their* invested interests in those buildings protected. They had gambled with the owners of those buildings that the latter would not be destroyed and had been paid to take that chance and it was nothing but the part of good business to in turn

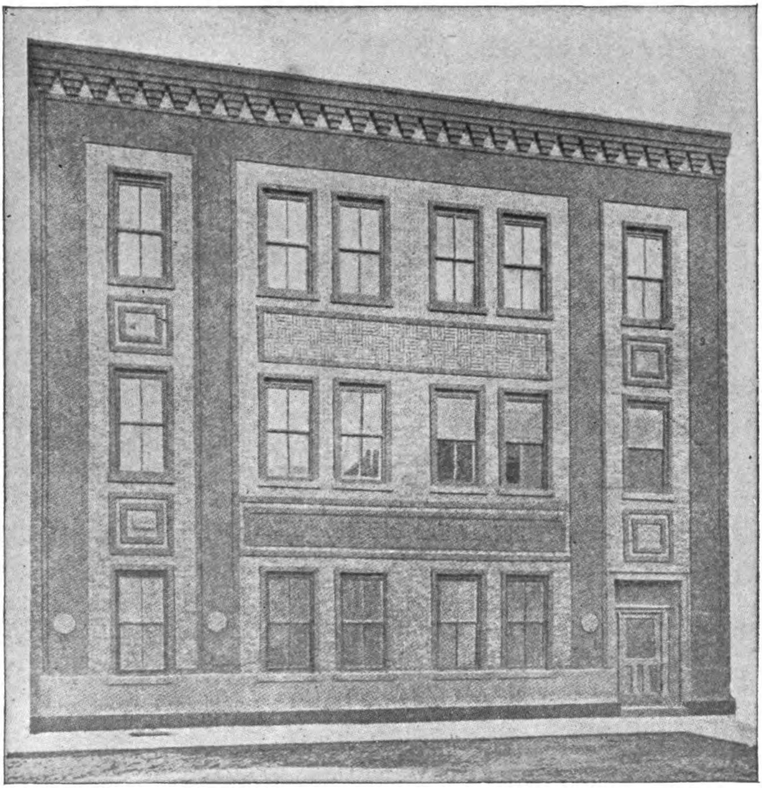


Fig. 51. The Exterior of the Underwriter's Laboratory at Chicago
The ideal fireproof building It ought to be added incidentally that it could have been made more handsome without in any way impairing its fire-resistance.

make the city insure *them* that fires there would be put out as soon as possible in order to minimize *their* possible losses. Figure it as you may, the cost comes back to the "ultimate consumer," he pays the insurance rates and also the taxes for the "protection" demanded by the companies for *their* interests. Stop and think how utterly

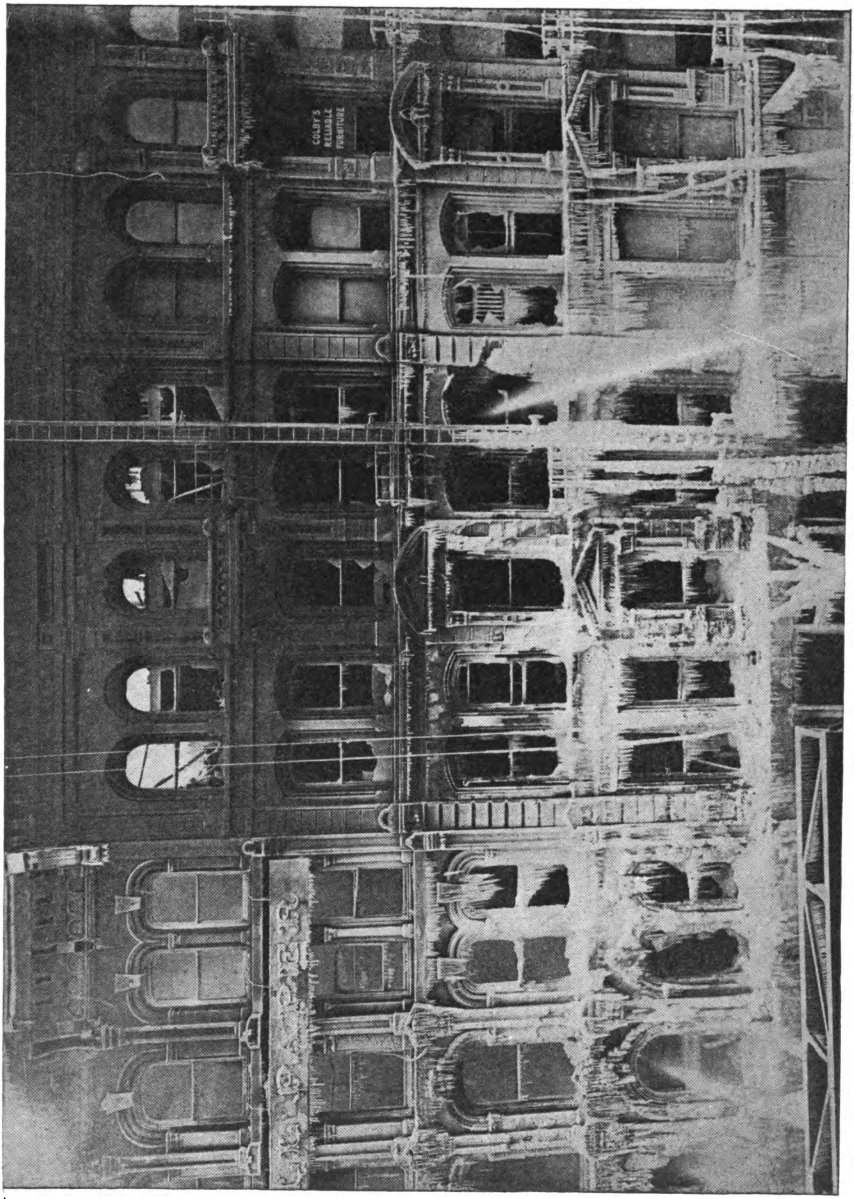


Fig. 52. Veritable "Whited Sepulchres"
Expensive fronts of granite and of marble but with wooden joists and partitions.

stupid he is to keep on permitting both ends, as it were, to be played against him.

The companies are in a position to enforce their demands, too. If their "requests" for water or more firemen or apparatus are not acceded to, up go the rates on that particular block and on the whole city. At times they have even withdrawn entirely from a city, cancelling all old business and declining new, until the mandates of their board were obeyed—an action which always brings a city to time. The reason is plain. The people become scared, the idea of not being able to get any insurance is indeed alarming, and pressure is brought to bear upon the authorities. Loan companies and banks call in their loans upon such uninsured property and for the life of you, you could not borrow a penny to put up another building. It has its effect upon all other business as well as building; the city is discredited, and it is not long before its council hastens to do just what it is ordered to do by the companies—an insidious but very present power indeed.

A commercial journal recently asked the question, "Do the Stock Fire Insurance companies really want fire protection?" and proceeds to answer it thus:

> This question is being asked more and more every day. Through the daily press, the companies are constantly preaching protection to the insuring public but what are they themselves doing to encourage, to make practical this protection? If the companies wanted to, they could cut the fire loss of this country in half and actually wipe out the *conflagration danger*.
>
> How can this be done? By a practical recognition of Fire Protection. The recognition at present given to Fire Protection is to a very large extent without result. The National Board of Underwriters "adopts" standards, it "approves" devices and systems, it "recommends" their use, but in this, as in other things, it is money that talks, or to put it in insurance language, it is "the rate that counts."
>
> What is the rate for Fire Protection? Is it given proper consideration by the rating organizations, that is, the local boards and exchanges?
>
> What steps, for instance, are being taken to find out the loss ratios for Protected Risks as against Unprotected Risks?
>
> What difference is made between approved devices and unapproved devices?
>
> Are the devices that have met all the specifications given a rating according to their efficiency as actual loss savers, or according to their value as underwriting safeguards, or according to their cost of manufacture and installation?
>
> Fire Protection has become an issue between the insurance companies and the insuring public.

The public is buying devices and systems that prevent and extinguish fire. When the property owner pays for the Fire Protection, he expects to save insurance premiums, because the use of these devices means less fire loss and this in turn should mean a cheaper insurance.

What are insurance companies doing to really promote Fire Protection?

There are two sides to the question, of course. The companies offer the bait to gamble and the people gobble it up with avidity, hook and all. The average man when building does not begin proceedings by inquiring how his building had *best* be constructed, but he asks what do the insurance companies insist upon. He figures on the most "liberal" or slovenly way in which they will permit building for a certain rate which he deems satisfactory, and the two together form such a combination as to make possible such appalling sacrifices to the demon of fire as we have witnessed in Baltimore and San Francisco and will witness, in due course, in New Orleans and in Boston, aye, and in a modified form in New York, and in Chicago and in Washington, too. There has been such an orgy of bad building that, do what we can now, in our newer structures, there is enough fuel in every city in the Union to give us in each—the conditions and "accidents" being propitious—nearly as great a bonfire as occurred in Baltimore and San Francisco.

Oh, yes, the people are to blame, as are the habitués of any gambling place. Two things are necessary to cure the evil; one is to educate the people as to the folly of ultra-gambling and the other is to regulate the gambling-house. The local agents of the different companies are interested, not in good building, but in premiums, and they will try their very best to get their companies to accept what every one recognizes as a questionable risk. Poorly-constructed and ill-protected buildings in congested districts have been and are being insured at such rates as to make the propagation of their species appear to be profitable. Innocent people who are guided by the slight difference in rates build their houses flimsily with the idea that it is economy; shysters and jerry-builders build flats of beautiful exterior and fire-trap construction, buildings that will look well for a few days until they are sold or rented, and what is more they get a moderate "rating" upon them, and city governments are too complacent to prohibit such construction (their efforts are generally in the direction of more water and larger fire departments), the individual does not know any better or does not care, and there you are.

For years people have "enjoyed," so to speak, these comparatively low rates of insurance until vast aggregations of flimsy buildings are everywhere about us. Then suddenly there is a big fire that the companies had not planned for or counted upon, and up go the rates upon the old as well as upon the new buildings, virtually a case of getting people in such a fix under false pretense. The San Francisco affair was along that line. A ridiculously low rate was made on buildings there, practically a 90 per cent frame risk. But the rate was made, forsooth, because San Francisco enjoyed the advantage of a most excellent fire department. Of what avail was it? What promise have we that similar or some other form of accident will not impair the usefulness of a dozen other fire departments? Now that the insurance companies have been singed there, some of them out of existence, up go the rates on everything new and old in San Francisco because it has been proven a "poor risk" and, at the same time, the rates have been raised pretty much everywhere else, so that the companies can recoup themselves for this run of bad luck. The accumulations of years in the sinking fund apparently were not sufficient to pay salaries, dividends, and these great losses, too. In St. Louis, for instance, the raise has been from 25 per cent to 100 per cent. Paper warehouses in the congested district have been mulcted $2.50 per $100 instead of the previous rates, $1.20; box factories $5.50, formerly $3.60; tobacco plants $1.95, formerly 90c; and so on.

I happen to have before me just now editorials from a number of Minnesota papers, growling about the excessive rates in that state. They complain that the companies have collected nearly $9,000,000 in premiums this past year, a sum equivalent to quite $4 per inhabitant. The losses paid by those same companies amounted to only $2 per capita while the actual fire loss was a trifle over $3 and in the cities the cost of fire department maintenance was quite $2 more. All this simply means that that state is keeping right in line with the averages we have noted.

It is commonly reported that many, probably one-third of the smaller companies (the mutuals and locals), had been, prior to the San Francisco fire, working purely upon their "nerve." That loss wiped out their assets and they were forced to the wall. Some of the insurance commissioners are my authority for believing that many more just such companies, not affected by that particular fire, are in no better condition. Another such drain upon the general funds and probably not over fifty companies, and those the big popular ones only, would be able to pay up.

Late reports show us that the United States stock companies (fire and marine) take in over $210,000,000 a year in premiums, the foreign companies doing business here (five only) $78,000,000, and the United States mutuals $35,000,000, a total far in excess of the average yearly rate given in our statement of average cost of Insurance. And these rates and premiums are, of course, increasing amazingly every year.

In France, in Belgium, and in fact, in most of Europe, they guard against incendiarism and also carelessness by making it impossible for a man to recover insurance for a fire that originates upon his own premises. Furthermore, neighbors whose property is damaged by fire originating upon his own premises, fire caused by his carelessness or neglect, have right of recovery from him. This has a wondrous effect in making people store waste paper carefully, look to their ash-barrels, and exercise some discretion in dallying with fire possibilities generally.

This one feature, the "neighboring risk," we should hasten to adopt, for it has long obtained in European countries and is an evidence of the very highest civilization. Its importance cannot be exaggerated. It would be worth more to us than 100 per cent increases in all our fire departments, for it would cultivate carefulness on the part of owners and occupants of buildings and make them cooperate with the fire departments in keeping down fires. It is something that has to be done by legislative authority and the insurance companies in unison. It would work to the latter's ultimate advantage, too, but so far, though we have long preached it, and its perfect working and admirable results in Europe must be quite patent to them, we are not conscious of the slightest efforts on their part to secure the necessary legislation to put it in force. It will have to be placed upon our statutes by dint of patient hard work on the part of a few fire-prevention "cranks." That is the road that has been traveled by every improvement so far secured.

To summarize: the real and only function of fire insurance is to equalize the loss and to distribute it among all those whose property is insured. The insurance on a burned building does not bring back the property that was destroyed. This loss is *absolutely irretrievable,* the property and all its value has gone *forever,* a waste, real destruction. And, furthermore, the indemnity, the insurance that *is* paid, is seldom as much as 75 per cent or 80 per cent of the real value of the destroyed property, generally but 52 per cent.

Insurance in some form will probably always be necessary, but since even with it the individual never gets back all the value that the fire destroyed, and never the premiums paid the companies, the sane thing to do would be to so build that insurance need only be carried upon the contents, and really only upon the average contents of one single unit of space in that building.

RAILWAY EXCHANGE BUILDING, CHICAGO, ILL.
D. H. Burnham & Co., Architects
Exterior of Cream-Tinted Enameled Terra-Cotta from Sidewalk to Cornice

FIREPROOF CONSTRUCTION

PART I

STIMULUS TO GOOD BUILDING

You may insure from now until doomsday, and in the best companies; you may install new water-works and buy new fire engines and devise new extinguishers; and you may train your firemen ever so skilfully and make them ever so expert, and supply them with however speedy and powerful horses and autos, but fire will keep right on destroying individual buildings and contents and lives and whole sections of cities, and at an ever-increasing rate and intensity, just as long as our buildings are built as they are now—the overwhelming majority of them. And the greater the volume of new building done, the greater the chances of fire and the hotter will it be, for nearly all of that new construction is but just that much more fuel, good dry timber, for fire to feed upon.

The only fire prevention I really know of is actually *prevention*—give fire nothing to burn and you shall have no fire. Cities and towns and hamlets are but more or less congested aggregations of buildings. But one out of every 1,500 of those buildings (and that *one* only in the larger cities) is even moderately fire-resisting, therefore the other 1,499 are but invitations to fire to do its worst, a foolish "dare" and one that is *taken* all too frequently. As matters stand you have one chance in 600 of being the *next* one burnt out in your vicinity. That is not such a very long chance, so even if you are not over-public-spirited, then just plain selfishness, self-protection, should prompt you to do all you can to make that chance the more remote. As we have observed we may do all we can, we may make all our new buildings perfectly fireproof, and yet there is already so much fuel all about us, so many million poorly-built fire traps, that we have enough to supply our present rate of fire-destruction for a good many years. It behooves us, therefore, not only to build our new buildings well but to make away with the old ones by removal before fire gets them, or, at least, so to correct their worst faults as to make them less certain of destruction—a lesser temptation to fire to get them.

Remember this first and great essential maxim in Fire Prevention: *The fewer combustibles you have around, the less fuel you supply, just that much less fire you shall have; if there is absolutely nothing to burn there can be no fire!*

We can get fairly near to that ideal only by being compelled to travel in that direction. It is a strange and perverse way we have of sticking to old ways, particularly to bad habits. We may know and feel that they are wrong but we stick, nevertheless. The "most progressive people on earth," we say, and yet we fight progress tooth and nail. Years ago smallpox was common and its ravages were awful. The thinking few, realizing that greater municipal cleanliness and vaccination would curb it, finally compelled the authorities to take these precautions—for the good of the people, mark you. The movement was fought back every step of the way; in places the troops had to be called out to quell riots; the people objected to being vaccinated. Of course authority prevailed and today smallpox is comparatively unknown. And just so has it been with every beneficial movement, its very beneficiaries have opposed it and made its progress oh, so very, very difficult. So with this fire matter. It is only by municipal, state, authoritative action that anything can be done. It will be a long day before the individual, if left to himself, will, of his own free will and inclination, build properly because he realizes it is for his own and the community's good.

Legislative Control. Legislative action is our only salvation and it cannot be secured too quickly. Much has been accomplished, cities are waking up, but there is still very much to do before we get far beyond the mere start we have made. And our authorities, being elected by the people, are retained in office as long only as they please the people, even though they know so well that this or that suggested legislation is for the ultimate good and advantage of, and is absolutely necessary for, the people.

The cry is often, that the building restrictions are for the benefit of the architects, or the builders, or this or that individual interest.

Nothing that can make building better and safer is of any more advantage to any individual than it is to the community.

Not only are good building laws combated, but when they are passed every effort is made to evade them. In this the owners of buildings are aided and abetted by their architects who, of all men, should know better and be the mainstay, the staunch support of wise and protective regulations. They will quibble with the building department officers and spend every energy in securing concessions, recessions from the letter of the law. They want to use thinner walls than prescribed, want to go higher in the air, leave structural portions unprotected, all sorts of ill-advised ways of reducing the cost of a building—generally at the cost of its efficiency. Architect and owner will work their friends, pull political strings, and some do not hesitate at even more criminal methods of having aldermen or mayor over-rule the building department and grant "special" permits for this or that building to be built not in strict accordance with the law. The "special permit" is one of the worst curses of a civic government.

There is no public ordinance that restricts the sale of comestibles lest a man kill himself by overeating, for, if he does, it is merely a warning to his neighbors not to do the same thing. The community does not legislate for the benefit of the individual. But there is propriety in legislation intended to prevent and control contagious diseases which may spread from the unclean or ignorant individual who originates them, to the community at large. Although no legislation aimed at prevention of contagious diseases is now held by the public too grinding and unendurable, and no disease that can affect the public welfare is more contagious than a conflagration, yet comparatively little effort is made by the public to deal with it preventively. Millions are spent yearly in handling the disease after it breaks out, but only hundreds in steps to prevent its outbreak. Looked at fairly, it is the community at large that is the culprit since it "suffers" fires to take place, when it really has the power to prevent them. It looks calmly on at the expenditure annually of millions, millions that come out of its own pockets, for the maintenance of imperfectly effective fire departments and insurance companies, and yet, if but one-fifth of the money spent in Chicago in this way had been divided among the improvers of real estate so as to cover, in the case of each improvement, the difference in cost between combustible and incombustible building, the greater part of the city would now be *indestructible.* This simple method could be adopted from today, and further generations would look with reverence on the men that devised this system and honestly administered the details of its application, the men, it might be added, who would have thus also protected their own property and safeguarded their own interests while looking to the welfare of posterity. The theory under which advances in fireproof building have been made hitherto is largely, if not altogether, a mistaken one. It has been the assumption that a real estate improver, as a sane business man, should be able to perceive how much it was to his own ultimate advantage to build an indestructible building and so save in the long run a large amount in insurance on building and contents. The true theory, we are convinced, is that incombustible buildings *must* be built. It is really immaterial to the taxpayers whether an individual elects to let his buildings be destroyed by fire, but it is of very real interest to the public that the property of other people shall not be destroyed at the same time. This once comprehended, it is easy to see that the real responsibility rests on the public and not on the individual. It is for the public then to examine the ways in which it can discharge its duty to itself, at least cost to the taxpayer, and here, as in the case of all other contagious diseases, time is the essence. It is desirable to substitute unburnable for burnable buildings with the shortest delay possible, since a conflagration may occur any day and the process can better be accomplished by coaxing than by compulsion.

Remission of Taxes. One persuasive device is the remission of all, or the majority of, the taxes on new incombustible buildings, until such time as the amount of taxes so remitted shall equal the difference in cost between an incombustible and combustible building of the same size and architectural character. Or some other scheme could be devised whereby taxes upon buildings would be rated according to classes of construction, a heavier rate upon poor buildings and a lighter rate upon fireproof ones.

Since the municipality has to provide protection in the way of fire departments, in mere justice to itself it ought to see that the minimum of protection is required. The reform in taxation suggested, added to the absolute prohibition of really poor construction, would be but a step toward ultimate municipal insurance against fire. The fire departments in themselves constitute the first step in that direction and are part and parcel of such insurance. Such a remission of taxes would be equitable to all. It would place the burden of paying for maintenance of fire departments upon those who needed the service and would relieve those of the tax who are public-spirited and business-like enough to build so as not to require such service. It is part of the solution of the problem and all right-minded men should join in the effort to bring about this much-needed reform in taxation.

Labeling Buildings. Next and immediately necessary, the authorities should conspicuously label every building of public or semi-public nature, just as to its class of construction, "fireproof," "ordinary," "dangerous". As it is now, the term "fireproof" is cruelly abused. It is applied where there is not the slightest foundation for its use and is made the means of obtaining tenants and occupants under false pretenses. A man with "dangerous" affixed to his building would have difficulty in renting it and that would be a powerful incentive to at least make the building better if he did not absolutely eliminate it and build correctly.

The effrontery or ignorance of some owners of buildings is most astounding. I have seen a hotel keeper put a metal ceiling under his wooden joists and some corrugated iron outside a kitchen annex, for instance, then affix a great sign with letters six feet high, informing a credulous public that his building was "absolutely fireproof". The public, always more or less gullible, accepts this at its face value and, feeling perfectly safe, goes to bed in that hotel—a building that would last six minutes in a good fire and from which one would be lucky to escape with his life. The misuse of the word is really appalling; the moment an owner does any one of the very many things that are required in a fireproof building he thinks he has received a sort of "immunity bath" and says, "*All* has been done that can be done to make that building *perfectly* fireproof and safe." Then there happens a bit of a fire, which is not confined to a small unit of that building, but spreads, thus calling more of the fire department into play, and causing more tons of water to be poured on. But it has too good a start, and that building and a dozen others are laid low. At the post mortem it is wisely decided that the building was not "fireproof," that no building *is* fireproof.

Neighboring Liability. We should also have the same municipal regulations that they have in most European cities relating to "neighboring liability," to which reference has already been made. These neighboring damages are always collectible at law in Europe and the regulation is one of the most effective of fire preventive measures.

Public Opinion. These are not heroic or revolutionary methods and yet, wherever applied, they would work marvels in the way of bettering conditions. There is too much apathy in this fire matter and the authorities who know what it really means are fearful of applying the restrictions that are needed, because, forsooth, some of these might too nearly touch powerful constituents or friends. We may hope to attain the desired ends only by forcing these authorities to do what is right via the pressure of public opinion.

It is passing strange how those things run, but interesting withal to find that in all reforms the masses have to be compelled to do certain things by authority; the authorities have in turn to apply compulsory measures by the weight of public opinion; and public opinion in turn is moulded by a few who think, who are public-spirited enough to take the trouble, and who are insistent enough to stick to their point until something *is* won.

But when once properly started that same rather laggard public is apt to become quite exacting over points in which it used to be so lax. When the government first began dabbling in pure food investigations the officers were jeered at, made fun of. There was no co-operation from the people or from the purveyors of food. Little by little the public was shown how injurious certain "preservatives" were, how cruelly befooled we had all been as to the true nature of certain well-advertised foods. The public went over to the correct view of the situation one at a time, then in twos, and later in droves. Today we are mighty particular as to the purity of the food we eat; we demand government inspection; we insist upon proper and truthful labels; we have "seen the light" and walk accordingly. The manufacturers, instead of refusing inspection, attempting to work in secret, throwing obstacles in the way of the Bureau as they did at first, now greet its officers effusively, they do exactly as directed, are anxious to make a great parade of "officially inspected" labels, and apparently are as desirous of giving the public what it pays for and thinks it is as the government officers are. The people have awakened and they cannot be befuddled into somnolence again—as far as food is concerned. So with fire. Get the people well awake and there will be a reaction. I venture to predict that in five years from now the "fire specialist" will be an important factor in our city life and that the insistent demands of the people will bring about healthy legislation on this all-important question.

A few quotations from a recent address of Mr. Wentworth, the able secretary of the National Fire Protection Association, will be illuminating.

A distinguished Englishman, Mr. Balfour, in recently reviewing the rise and fall of civilization, says that the main hope of the future lies in the popularizing of scientific knowledge. There could scarcely be another observation that would strike more clearly the very keynote of our own thought and endeavor.

Fire prevention is a science; a science which ramifies and becomes more elusive as civilization becomes more complex; but which, when mastered, is wholly academic and impotent for any large measure of good until it is popularized and made an integral part of the common intelligence.

An average of $250,000,000 per year for five years, or $500 per minute for every hour of the twenty-four, is our country's contribution to the property ash-heap of the world.

And yet I have not come to you today to quote the statistics of the American fire waste, the shameful barometer of our national carelessness and folly; nor to make melancholy predictions of our national bankruptcy should such stupendous and unnecessary waste continue. Of these humiliating conditions you are well aware, the very existence of your organization is a voucher of their recognition, even if the conflagrations at Dallas and Fort Worth did not offer their blackened ruins as a mute reminder. It is rather my present mission to join you in seeking the means and methods whereby we may rescue our country from those embarrassing criticisms which European prudence is coming so harshly to visit upon us.

The National Fire Protection Association, of which body your organization is a valued and appreciated member, has for more than a dozen years devoted itself to the consideration of fire hazards, and the compilation of standards calculated to instruct the common understanding on the subject of the fire waste. One might venture to say that there is hardly another public service to which has been given so much of valuable time and voluntary research by skilled and capable specialists and engineers. Year after year these standards have been discussed in the light of cumulative experience and revised and amended under such discussion, until they now represent the most valuable and authoritative guides and data modern knowledge can produce.

ing to be vaguely understood and desired. But fire-stops and fire-extinguishment—these have not yet appeared above the horizon of the common mind. To ask the modern city to purchase and pull down enough of its old rookeries to afford occasional broad streets as stops to possible conflagrations is a good deal like asking for the moon; and yet half of a city might be saved by such a pathway in enabling firemen to confine fire to the section in which it may originate. What cities may obtain by open spaces, the factory may obtain by fire walls which divide it also into sections to which fire may be confined. While, however, such fire walls, if carried well above roofs and equipped at their openings with standard fire doors, are a good general factory precaution and seldom fail to hold fires in check, there are certain factories in which fire-stops should be thrown around all hazardous processes. We now have sufficient statistics on almost every well-known manufacturing process to indicate just what elements in such process are especially susceptible to fire. Bulwarked by this knowledge, it ought not to be difficult to induce the manufacturer to segregate from the principal values of the factory all special processes demonstrated by experience to be especially hazardous. This does not mean that such processes must be carried on in separate buildings at the cost of traveling time and inconvenience. The problem of segregation can now be met without shifting the process out of its logical place in the routine of manufacture. In a fireproof factory only a separate room, or at best a separate floor, is needed. The manufacturer who once, when he had a fire in some room where volatile oils, for example, were used, commonly lost half his plant, or at any rate so drenched his premises with water as to have to make a fortnight's suspension necessary, can now, if he likes, so dispose that hazard as to have a fire every other day without disturbing the other parts of the factory. The modern fireproof room equipped with automatic sprinklers, having a slightly pitched floor and scuppers at the walls, can be flooded for fire extinguishment without a drop coming through below. The water runs as harmlessly from it as from the deck of a ship. If we can get, in addition to such consideration as this, enclosed stairways and elevators and belt shafts, we can be reasonably certain that even a small fire department will confine every fire to the floor upon which it starts, even if upon its arrival the automatic sprinklers have left it any fire to fight. The sprinkler system is now so well known and its value is so commonly recognized that few manufacturers remain to be convinced of its virtues. Where the sprinkler system fails it will in almost every case be found to have been neglected previous to the fire. With a fireproof structure, segregated hazards, standard fire-stops, and a proper sprinkler system, we might well breathe more freely respecting factories and turn our attention to our friends the merchants.

In mercantile risks, although many in the larger cities of the country are equipped with fire-stops, the conditions in most of our smaller towns and cities are but invitations to conflagrations. The principal mercantile values are, in cities of the smaller class, usually massed together within the radius of less than half a mile. I have explored many a double row of brick stores, divided by a sixteen-foot alley, and have found in almost every one piles of goods stacked against the rear windows, scarcely a workable fire-shutter in sight and not a metal window frame in the city. Many watched the fire go through brick walls last year in Chelsea, Mass. The wooden frames of the windows would ignite, the glass would crack and fall out and each story of those brick buildings became a horizontal flue, filled with burnable material. Every brick building should be in itself a fire-stop. If every mercantile risk were equipped with standard metal window frames with wired glass, a conflagration could hardly get started in the center of our cities. Such a window not only keeps out fire, but it keeps fire in—so it may be extinguished in the building in which it starts. There is not a city in the country, including even Boston and New York, in which conditions are not ripe for a conflagration. In the smaller cities especially, conflagrations are sooner or later inevitable. They await only the conjunction of a fire in the right quarter and a windy night. Here then is a field for our immediate agitation—the reduction of the conflagration hazard of the entire country by the easy conversion of every brick, stone or concrete building into a fire-stop. This is popularizing science simply by laying upon it the finger of common sense. In the same category, the category of common sense, fall the matters of the storage of inflammable oils and explosives, the wiring for electric light and power, and the construction of flues and the building of those fire-boxes for homes in which open spaces back of walls enable a fire to be located in the basement by the flames breaking through the roof.

Indeed it may be that the major portion of our effort lies wholly within the domain of common sense and following effective agitation the people themselves may initiate the desired corrections, appealing to our fraternity only for special service. It is certain that there is growing in American communities a feeling that every individual is responsible to the collective life. "Civic consciousness" as a phrase is set over against that much over-praised individuality which is so close to anarchy. If civic consciousness means anything at all it means a united effort for the general good and a united recognition of common danger. No one who has witnessed a conflagration or has been the victim of one will maintain that a common effort to eliminate the hazards of such a calamity has not the first vital place. Where there is no law to restrain the careless and irresponsible, such a law should be enacted; and where laws are ineffective or obsolete such laws should be rewritten. Public recognition should be demanded for the fact, so hard to impress upon growing communities, that increased fire protection and a more efficient fire department are imperative when a city has doubled its size. The state as well as the city should meet its proper responsibility, and by means of a fire marshal's office and a vigorous inquiry into fire causes, stamp out the vicious incendiarism which it seems now so hard to convict.

It behooves us, then, as fire prevention engineers, while never neglecting those scientific developments and betterments which give to our profession its special social value and dignity, to keep our fingers constantly upon the pulse of the common life; to stimulate, where they already exist, those influences which make for the common welfare and safety; and where they do not exist, to create them. This is our double function, to know and to lead others to know, how the cosmic element of fire may be harnessed to the service of the race without smiting it with horror and destruction. Individually in a civilization so complex, we may perhaps do but little, but as a fraternity, as soldiers of the common good, we may inspire a thousand monuments of better building that from sea to sea shall stand as a testimony to our service, as proof of our manhood in our day and generation.

PRESENT BUILDING CONDITIONS IN AMERICAN CITIES

Large Proportion of Poor Buildings. We have noted that but one out of every 1,500 of our buildings is at all fire-resisting. Nine-tenths of the others are wooden frame buildings—wooden walls, roofs, joists, partitions, finish—wood everything. Besides being of well-seasoned and dried wood, all that timber is painted, oiled, varnished, which makes it burn quicker, and, furthermore, it is arranged with such air spaces, continuous flues between floor joists and between studding, as to insure the easiest and most rapid transit of fire from cellar to attic. The other tenth of our buildings have a shell of good material encasing them, outer walls of brick and stone, and slate or metal roofs, but those walls and roofs are conveniently pierced with door-ways, windows, and skylights, protected only with wooden doors or glass sash, easy egresses and ingresses for fire. It is fondly hoped, of course, that fire will spend its attack on those resisting walls and not go through the feeble defense offered by those apertures, that half the time are left invitingly open. Further than that shell, nothing is done to prevent or minimize fire. In all of those buildings there is the same kind of wooden joists, wooden partitions, paint, and all; or, perhaps, the columns and beams are of semi-fireproof metal, which will not burn, of course, but being unprotected, will so twist and buckle in fire as to do as much damage as if they were really wood and did burn up.

These *good* buildings, with their conveniently pierced unburnable shells, may not be consumed as quickly as the entire wooden buildings, but they assure the spread of fire into conflagration proportions just as successfully as do the wooden ones.

Major Sewell, an army engineer who has given a great deal of study to fire, aptly puts it thus:

> The glaring faults of commercial districts in American cities is the general weakness of individual buildings, and of districts as a whole, against an attack in force from the outside, which in this case means a developed conflagration. The Committee of Twenty, in discussing the conflagration hazard, soon began to differentiate between the "probability hazard" and the "potential hazard," the first referring to the probability of a fire getting beyond control and out of the building in which it started, thus becoming a conflagra-

tion, and the second to the strength it would develop in sweeping a district; in this is involved the amount of food the fire would find in its path, as well as the facility of ignition and transmission to neighboring buildings.

In the writer's judgment there is not, in a single American city that he has visited, any district of appreciable extent that would by its own passive resistance either stop, or appreciably retard, a well-developed conflagration. It is just possible that a conflagration of limited front might be delivered against the mass of so-called fireproof buildings in the financial districts of Manhattan, and not get through, but even this apparently well-fortified position could easily be flanked out, and it probably would be by any conflagration likely to attack it; and the conflagration hazard in Manhattan is almost bad enough to be called *an impending disaster*.

The essence of the whole question of resistance to conflagration is the protection of necessary openings and the elimination of all that are not necessary. All openings should be protected, whether on principal fronts or not, unless they are separated from all dangerous neighbors by wider spaces than any of the streets in any commercial district in the United States. In the completion and trimming of exposed openings, nothing but incombustible material should be used and it should be so applied as to resist fire for an appreciable time. The entire exterior of a building should afford no food for a fire, and so far as possible should resist its access to the contents within, whether in the form of radiant heat or otherwise. Any degree of resistance is better than none, and the possibilities of an effective active defense behind protected or partly-protected openings was well illustrated in the several cases at San Francisco.

Good Buildings "Skimped." Even the one building in 1,500 is only partially fireproof, for generally something has been left undone or neglected that will vitiate what has been done well; so that a fire in the neighborhood or inside the building could damage the structural part anywhere from 10 per cent to 85 per cent of its full value.

Like a chain a building is only as strong—from the fire prevention point of view—as its weakest link. And our architects and engineers have, alas, heedlessly, thoughtlessly, or ignorantly supplied not one, but several weak links in our most expensive buildings.

Think of it! Had just one thing been done more than was done in San Francisco, in its big buildings, before the fire, if they had protected the windows of those skyscrapers with wire-glass or with effective shutters, an additional cost of perhaps $60,000 for all those buildings, their contents and fittings would certainly have been saved, a salvage of at least $10,000,000. Just a while ago there was a big fire in New York, which did a damage of $2,000,000. That fire was made possible because they had "saved"

$4,000 in cutting down on the fireproofing of a $300,000 building!

There really is but one absolutely perfect building in the country, the National Board of Underwriters' Laboratory at Chicago. It was built to show how a fireproof building should be built and in it are made the fire and other tests of building materials, appliances, etc. The hottest fire you could build about it or in it wouldn't do $100 worth of damage. Its walls are of brick, it has protected windows, its structure is of steel and hollow fireproofing tile blocks, there is not a particle of wood about it and the materials used that could be damaged by fire, steel for instance are amply protected with material that is undamageable. And the extraordinary thing about it all is that it cost initially but 10 per cent more than if it had been built the usual way, wooden joists, etc.

There are a number of *almost* as perfect buildings, some of the great office structures of New York and of Chicago and some warehouses, but in all of them there is apt to be some one or more flaws, imperfections—and in every case it would have been as easy and inexpensive to do the thing right as it was to do it wrong—something that makes it possible for fire to do more damage to (though it could not destroy) these buildings than it ever could to the Laboratory in question.

Comparison of Conditions Here and in Europe. We suffer more by fire than any other nation on earth, for we have so few perfect or even good buildings; and yet we know more about fireproof construction than any other people, and have made greater advances in devising systems and in perfecting materials. In Europe they have no building that is anywhere as thoroughly well built, or fire-resisting, as the Singer Tower, or any one of a dozen skyscrapers in New York or Chicago. But here the general character of the ordinary buildings is so poor, so fire-inviting, that when you build one that is to be "fireproof" it has to be superlatively so to resist the intense heat and terrific blaze of a neighboring fire that is well-nigh beyond control. In Europe *all* the buildings are more fire-resisting, there is less wood used, greater care exercised to prevent fire; therefore the average fire is of such low intensity and so slow that it is easily handled in consequence. No building need be so very excellent, and none is, but the general average is better than ours.

The proportion of our "fireproof" buildings may best be shown by a specific example. Chicago is really the home of fireproof construction; it was first done there and probably more advances in the art have been originated there than in all the rest of the country together. Yet in its downtown district, its densest business section, that bounded by the Lake, the Chicago River, South Branch, and by Harrison Street, 90 blocks, there are 1,863 buildings, large and small, or an average of about 20 per square. Many of these buildings, too, are huge affairs, covering a quarter or half a square. They also average 7 stories in height with the maximum in the twenties, and an approximate valuation of the property is $270,000,000 or about $3,000,000 per block. Of all those buildings there are but 105 in which some attempt has been made at fireproof construction, and some very feeble attempts, too, though, of course, some of the best buildings in the world are among those 105. The district is known and referred to in fire-reports, insurance bulletins, etc., as the "fireproof section." Less than 6 per cent of its buildings have the slightest claim to that term! In that district the expectation and average is 50 fires per year per 1,000 buildings. Think of the danger the good buildings are constantly exposed to!

In New York the conditions are parallel. Just in one district, the "drygoods district," there are goods to the value of $500,000,000 stored in buildings, scarcely 6 per cent of which are even moderately fire-resisting.

VALUE OF FIREPROOF CONSTRUCTION

Instances are so numerous of destructive fires in supposedly fireproof buildings that many persons have absorbed the idea that there is no such thing as a building that will not burn. This error is entirely due to confusion in the use of terms and a misstatement of facts.

A building that is of non-combustible materials is not fireproof. A building that is of fireproof materials, but not of fireproof design, is not fireproof. A building that is not of fireproof construction and design except in part, is not fireproof. A building that is strictly, thoroughly fireproof, yet filled with combustible contents, may have a destructive fire *in it*, but the building itself will not be wrecked or destroyed. Experience has demonstrated again and again that if a building is of strictly fireproof materials—is correctly designed—only a small proportion of the contents can be destroyed by fire.

Importance of Good Design. The following illustrates the importance of the designing of a fireproof building:

The city of Philadelphia put up a half-million dollar high-school building which was of thoroughly fireproof construction clear to the roof. This splendid structure was then covered with a highly combustible roof and, to cap the absurdity, a tower was run up above the roof and this tower was built entirely of wood. A fire started in the tower, destroying it and the roof, damaging in part the two upper floors of the building and causing incalculable loss in the destruction of scientific records and a heavy loss in valuable astronomical instruments. And people of the city from the mayor down were asking how could such a disastrous fire occur in a fireproof building.

Lincoln said: "This nation cannot exist half slave and half free". A building will not exist that is half fireproof and half combustible construction. A truly fireproof building is one that is of thoroughly fireproof construction, non-combustible finish, and of correct design, so that a fire starting in any part of the building will be confined to the starting point, thus saving not only the building but the major portion of the contents. The correctness of this kind of construction is being constantly proved by the fires which start in fireproof buildings and, being confined to small area, are easily extinguished and cause such slight damage that they create no attention. The world never hears of them.

Fireproofing as an Investment. There are just two things that produce wealth, those two things are land and labor. You must have land on which to erect your buildings; you must have labor to find or produce the materials and put them in place. If you use the building to live in as a home or give it away as a home to others (as a means of gratifying your sense of philanthropy), then the building represents wealth to you, because it is used to gratify desire. If you use it to rent to others or to conduct your business in, or in any way to make money from its use, it represents capital, because it is wealth used to produce more wealth.

In every investment the first consideration is that of safety for the amount invested. The next question is the amount which can

AN AMERICAN FOREST FIRE

Such Fires Do Damage to the Amount of $50,000,000 Every Year and at the Same Time Reduce the Supply of Lumber to a Very Material Degree

be earned on the investment. Then comes the element of certainty that the earning will be continuous. Right here, in these first principles of investment, is where investors in buildings make their greatest mistakes. As to the land, the investment is safe—it cannot burn, be blown away, be destroyed by flood, be injured by wear and tear or fall to pieces from old age; nor does it require repairs.

The investment in buildings is subject to all these hazards; chiefly to the danger of fire, certainly to loss from repairs. "Hazard," "danger," "loss," are ominous words when we talk of investments. They smack of speculation. And the man who puts his money into the average building today is simply a speculator. He takes long chances in the hope of greater gain. The first and prime danger he faces is the destruction of his investment by fire. This is the great practical hazard which every building owner most fears. Under modern methods of building construction this danger can be eliminated. No building owner need assume the hazard unless he chooses to do so. He can have a building which is absolutely proof against destruction by fire, or he can take the other alternative and speculate (with the insurance company as a partner) on the building's eventual loss. This responsibility rests upon the investor himself. He cannot shift or evade it. He cannot put the burden upon his architect, upon his contractor, or upon the fire insurance companies. The architect and contractor will do what they are told to do and are paid for. The insurance company will simply become a partner in the gamble as to the destruction of the building; and, win or lose, the insurance company must be paid its charges.

The architect and contractor who serve their clients' interest *will advise* fireproof construction, but they *cannot* command it. The insurance company has no choice. If the investor chooses to speculate he pays a speculative premium. For the greater risk he puts up a higher margin. It is his money, his investment, his responsibility. The investor can make no half-way choice; his building must either be safe or a risk. He can speculate or he can invest. If he chooses a safe building he must know for himself that it is safe; he must study and inform himself, so that if he says, "I want an absolutely fireproof building" he will know whether he gets it or not. If he does not know he can blame no one but himself, for his ignorance, for channels of correct information are open to him everywhere.

It is a curious fact that a man who will investigate for months before investing in a piece of land will put twice as much money into a building without any attempt to secure knowledge about the structure, except to know that it gratifies his ideas of convenience and appearance. His first requisite in every other kind of investment, *security,* he utterly ignores when he puts his money into a building. Now let us see what a little thought on the subject would do toward solving the problem as to whether the investor or the speculator eventually makes the most money. Let us assume a case such as occurs hundreds of times a year.

Fig. 1. A Warehouse Fire
Nearly a hundred of these burned in a day is the record

Mr. Smith and Mr. Jones are competitors in business in the same town. Each decides he needs a new building. Each goes to the same architect and tells him to make plans for a building of a given size. The architect, after some figuring, tells both of them that he can plan a building of ordinary construction for $100,000 or a fireproof building for $110,000. This 10 per cent difference in cost between a safe building and an ordinary building is the average difference. Mr.

Smith says he does not need a fireproof building—that he will carry insurance to the full value of the building—that fire is only a chance anyhow and he will save his $10,000 and take the chance. Mr. Jones says he will invest the additional $10,000 to secure a first-class building that will endure—that even if he carried a full insurance he

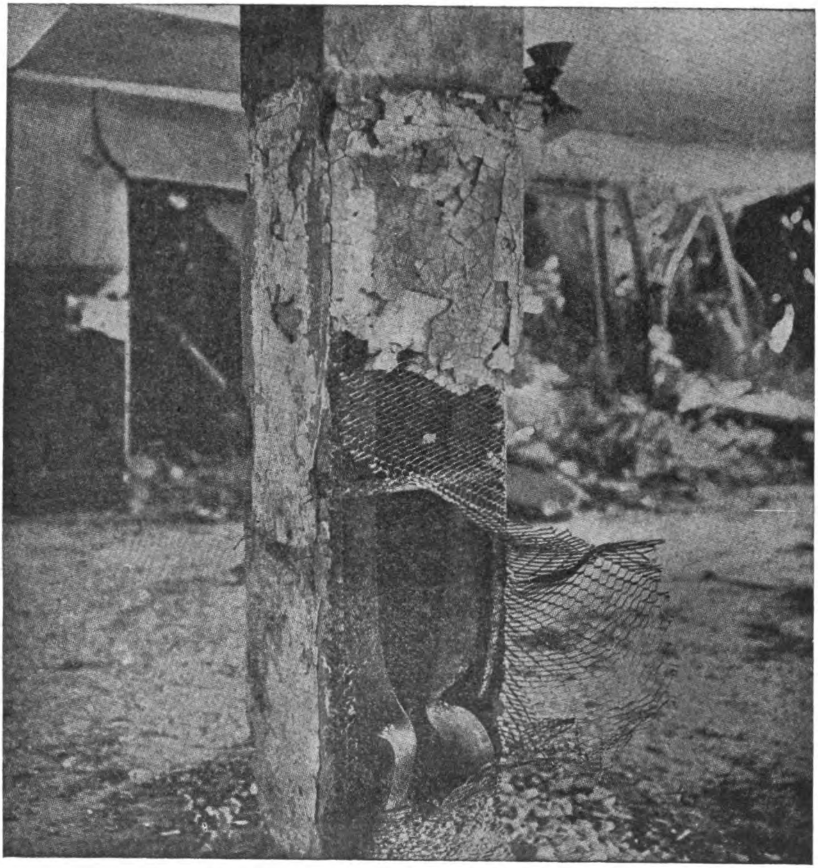


Fig. 2. A Wire and Plaster "Protection" to Steel Work

might burn out anyhow and the loss of business on account of the fire would be so serious that he prefers to take no risks. On this basis the buildings are finished and occupied. At the end of five years the two owners compare notes. Neither has had a fire but Smith's building is deteriorating—costs a little more each year to keep in repair, and *he has spent for repairs so far $2,000. He has paid out for insurance a rate of $1.50 on full value, or $7,500 for the five years. Jones has spent about $500 for repairs and his building is as good as the day it was finished, simply because it has been built of indestructible, vermin-proof material. He has carried $20,000 insurance to be safe under the 80 per cent insurance clause and his rate has been $1.00. Total insurance premiums $1,000. In five years Smith's investment is $109,500 against Jones' total of $112,500. In one year more Smith's building will have cost him as much as Jones' and Jones will have had and continue to have a better, sounder, safer building, while Smith's building may be completely gutted by fire any day with all the consequent loss of business and profits. In any event it is deteriorating at an ever-increasing rate, while the deteriorating of Jones' building is negligible. Mr. Smith as a speculator takes all the chance, yet in the long run, even if he has had no fire, he makes less money on his capital, and less and less each succeeding year.*

Insurance vs. Fireproof Construction. Reverting to the insurance phase of the matter in its direct bearing upon fireproof construction, let us sift the thing out a bit further. Fire insurance in this country, whether designated *mutual* or not, is simply the working of a mutual interest; it is exactly similar to the strike benefit fund of the labor union. Among the labor unions a million men get together in a federation composed of one hundred local unions of ten thousand members each and agree to pay into a general fund, called *the strike benefit fund,* certain assessments, premiums, or dues, from each man's wages, this fund to be used to insure the members of a local union and their families against starvation in the case of a strike.

In the case of fire insurance the difference exists only in the method of organization and its principles. A federation of fire insurance companies is formed, and a million owners of buildings say, "We will pay into this federation a certain percentage of the value of our buildings, and when any one among our million members has his property destroyed by fire, he will be reimbursed from our general fund."

One might very properly question, however, whether this is the best fire insurance that has been or can be devised. It readily appears that insurance does not prevent fires; on the contrary, the tendency would be to increase them, because a man feels less responsible when he is insured, just as a labor union is always more willing to srtike when it knows that its strike benefits are on hand. There are few things that will prevent fires and those only in a measure, viz, *constant vigilance and the exercise of great precaution*. There is only one thing that will prevent a fire from doing great damage after it has started and that is *fireproof construction* of the building. The func-

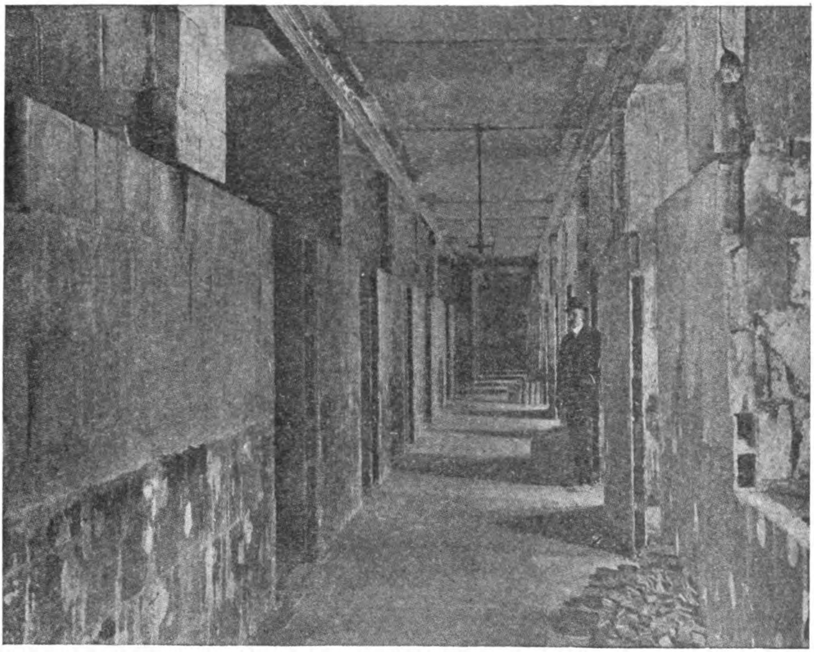


Fig. 3. Wooden Sash in Tile Partitions
This construction permits fire to travel from room to room

tion of fireproof construction is to hold a fire in the spot in which it starts, to prevent its spreading, and to protect the structural parts of the building from destruction.

The element of vigilance is presupposed in any kind of building. Witness the employment of night-watchmen, the introduction of adequate water supply, of sprinkler systems, of rules and regulations for the handling of combustible goods and rubbish, and for the management of engine rooms, heating apparatus, etc.

The question, therefore, is: Is it better insurance to occupy

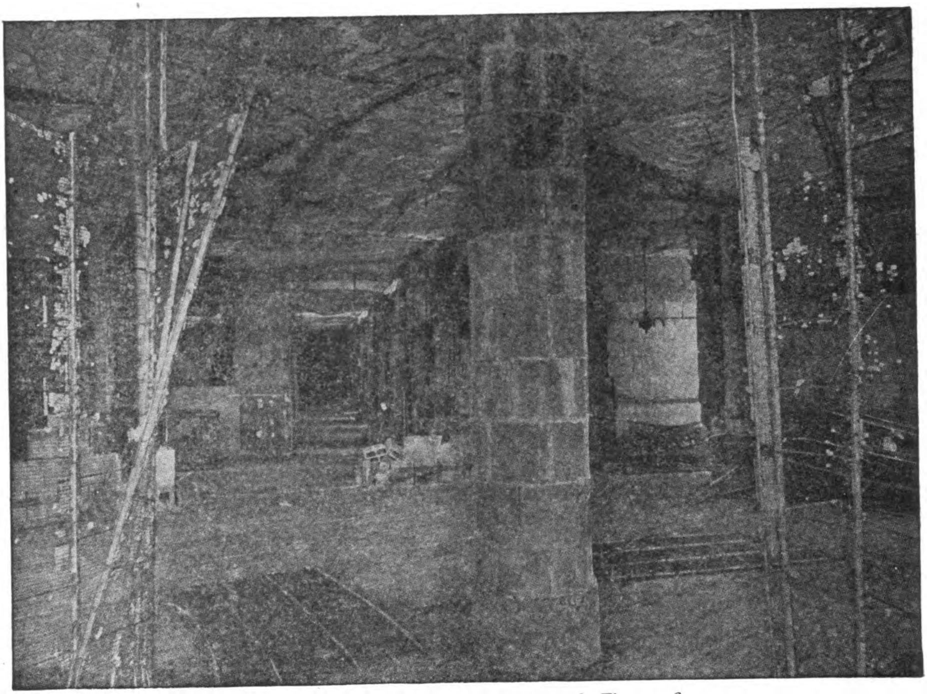


Fig. 4. Well Applied and Properly Made Fireproofing
This protects the structural parts of a building from fire's worst attacks

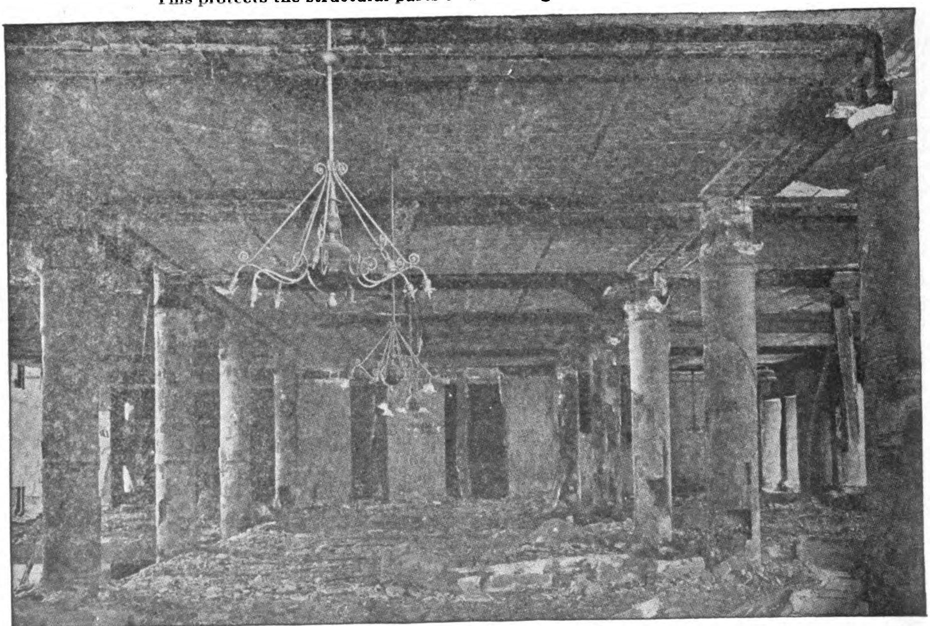


Fig. 5. Well Applied Fireproofing Protection Always Protects the Structural Parts

a building of ordinary construction and depend, in case of fire, on reimbursement from the federation fund, in the meantime paying out heavy premiums on nearly full valuation of the property; or to build in the beginning a structure that will not burn and that will limit the damage due to any fire started in it to a nominal loss, making it necessary to carry only a nominal insurance in the federation?

In the first instance the property owner has a smaller investment in the property to start with, but he keeps adding to his original investment with the premiums which he is constantly paying out.

On the other hand, if he builds a fireproof building his initial investment is greater by about 10 per cent, but it can be conclusively proved that in the course of a few years this additional investment is returned to him, for his building represents practically as valuable an asset as it did when first constructed. Therefore, *fireproof construction is the best fire insurance.* The insurance companies reluctantly say so and they back up the statement by some (inadequate) rebates in rates for thoroughly fireproof construction.

How does the fire loss really affect the owner of a building? In other words, what does insurance insure?

A man, or a company of men, who have a business building erected, do so because, first, a building is wanted in which to conduct business; second, it is put up to rent to others as an investment. In any case the danger of loss by fire is recognized and the owner figures that by covering his property fully with good insurance, he will recover his losses in full should his building burn. But will he? Suppose John Smith and Co., clothing manufacturers, put up a building costing $100,000. They insure it for full value at a rate of one dollar and fifty cents per hundred dollars, put their stock and equipment in, and begin to do business. At the end of three years the building and contents are totally destroyed by fire. The building has now cost them, with the insurance premiums added, $104,500. Assume that they are fortunate enough to get back the full amount of insurance, $100,000. They do not get the premiums back. That is a loss of $4,500. Three to six months' time is lost in erecting a new building, getting new equipment and new stock, and orders they had on hand unfilled are cancelled on account of delay. A loss of business of, say $100,000, and a loss of profits of $10,000. Stock on hand which had been bought at particularly advantageous prices has been destroyed and the old prices cannot be duplicated—further loss of profits of $2,000. Through loss of records of orders and the records of items in dispute, which make it impossible to prove ledger accounts, a loss of another $1,000 occurs. The rent of

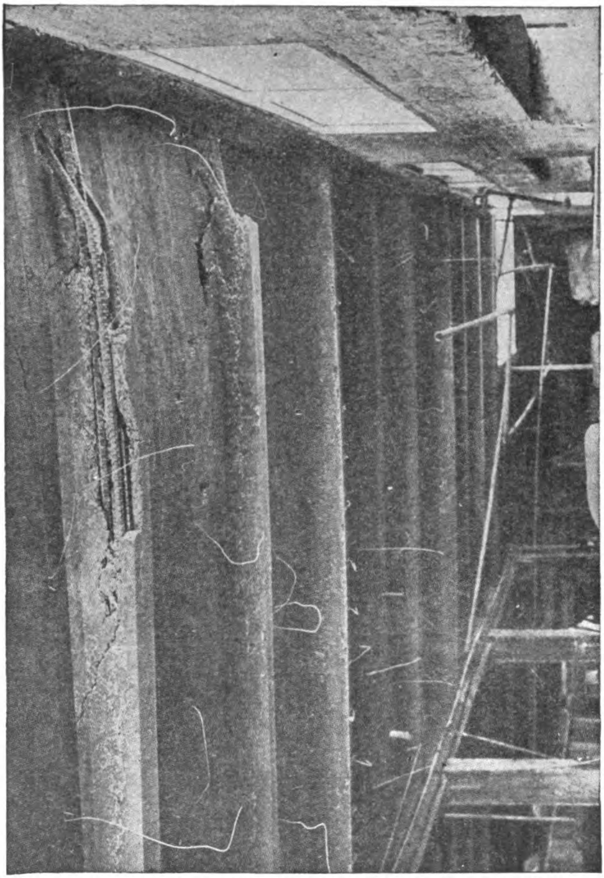


Fig. 6. Fire's Tendency to Expose and Distort the Reinforcement in Reinforced Concrete Work
This means total loss of the floor or column or wall

quarters in which to do business while the burned building is being rebuilt, costs, say $3,000 more. Moving stock and equipment into the new building when completed costs $1,000. Loss due to old customers getting away and making other buying connections cannot be even guessed at, but it must be a very considerable item. As a direct result, then, of the fire, there are known losses amounting to $21,500 which insurance does not and cannot cover, besides other losses which cannot be known or computed. And this is but one of a hundred actual, specific, record cases; in the case of a fire where the destruction is not total, these auxiliary losses will still be just as great in proportion to the damage done. So much for the losses in a building erected in which to conduct business. Now take the case of a building erected as an investment and rented to others. Assume the cost of the building to be the same as the one cited above, same character of building, insurance premiums the same. Annual rental of the building $8,000 or more. The owner loses at least one year's rental and his insurance premiums make the total loss $12,500, assuming that the fire occurs three years after the building was erected. In every case, of course, the longer the building stands, the greater is the amount paid out in insurance, to say nothing about the cost in repairs. Should a fire not occur for ten years the owner has paid out in insurance premiums $15,000. Now the moral of all this is, that the owner should consider all these questions when he is deciding the point as to whether his building shall be built of fireproof or ordinary construction.

Fallacious Arguments Against Fireproofing. Plausible arguments can be advanced against the bettering of conditions. A journal devoted largely to the lumbering interests in a recent editorial, gives one of the best examples of modern sophistry that has ever come under my observation. It says, summing up its argument against a general improvement in building conditions and the lessening of fire risks:

> Our social system is adjusted so as to distribute the burden of the vast loss indirectly upon the public at large, and more than this, it not only expects to meet these annual losses, but it would be a very serious matter if these did not occur for a series of years. . . . The first year in which no fire occurred would cause general jubilation, fire companies would welcome the rest and stockholders in insurance companies would be happy in increased dividends.
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> Later, mechanics and business men would wonder why times were getting so hard. . . . And still later there would be a widespread outbreak of incendiary fires as the first step toward restoring the building industries to their normal condition. It is fortunate, therefore, that the progress in replacing combustible with incombustible building is, and must be, slow!

Comment is hardly necessary, though one little illustration may be of service to those weak enough to be impressed by such an attempt to mislead as the above. I have in mind a man who two years ago built himself a house costing $6,000. He had been moderately prosperous and was thinking of building a more expensive home, and

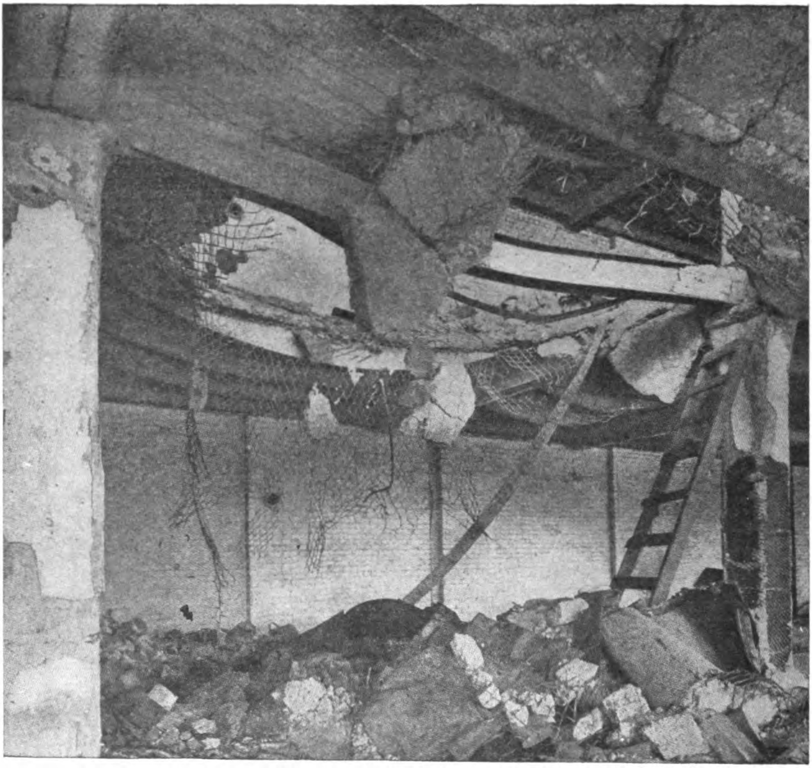


Fig. 7. Sometimes Reinforced Concrete Gives a Poor Account of Itself in a Fire

had already placed his present house on the market, and with reason expected to make a few dollars out of it on account of the increase in the value of the property. The house burned down. It was a total loss. He also lost all his furniture, some curios of considerable value, and much wearing apparel, etc. Like most men, he was but "safely" insured, and lost considerable by the fire, besides the expected profit on his sale. He is a man who will not rent a house, so he is boarding while building another home upon which he does not feel justified in spending a penny more than he did on the first, in view of the losses he has suffered. By reason of the fire our sophisticated editor deems it necessary to keep builders going, the latter having lost the prospective two or three thousand dollars they would have made in the due process of change and betterment ever going on in the world, had my friend *nct* burned out. Incidentally, whilst upon the subject of houses, it may be well to add that it requires just about 100,000 new houses a year to supply our regular increase in population—not taking into account those that are built to replace burnt ones or to supply the desire for better accommodations.

Fireproofing Real Economy. From the pecuniary viewpoint fireproof construction, I contend, is a real economy. Eliminating the question of insurance altogether, the depreciation on an ordinarily constructed building, office, store, or other business house amounts to at least $1\frac{1}{2}$ per cent a year; that is, apart from the cost of refurnishing and maintaining the building in presentable appearance, the materials used in its construction are decreasing in structural value to that extent. In houses used for dwelling purposes, apartments, etc., the rate is even greater, amounting to as much as 3 per cent. These figures represent the average of all the materials incorporated in the building; the depreciation of the essentially structural parts of timber is even greater, being nearly 4 per cent per year. On the other hand the average lessening of value of fireproof structure as a whole is a scant $\frac{1}{9}$ of 1 per cent, and the depreciation of the structural parts, when once properly built, is virtually *nil.* The constant shrinking and "movement" of wood framing necessitates frequent repair of exterior and interior finish, papering, painting, plastering, etc., even when those parts of the work would otherwise be perfectly presentable—undamaged by mere age; in a properly built fireproof building such things as shrinkage and movement do not occur. In ordinary buildings vermin—a thing few people figure upon—cause not only quite an additional expense, but actually a certain amount of damage to the building and its contents. The renting value of a vermin-infested house, flat, or store, is soon appreciably decreased. The cost of fighting these pests of various kinds is a tax and it may perhaps be surprising that, taking a dozen apartment houses, here in Washington for example, the

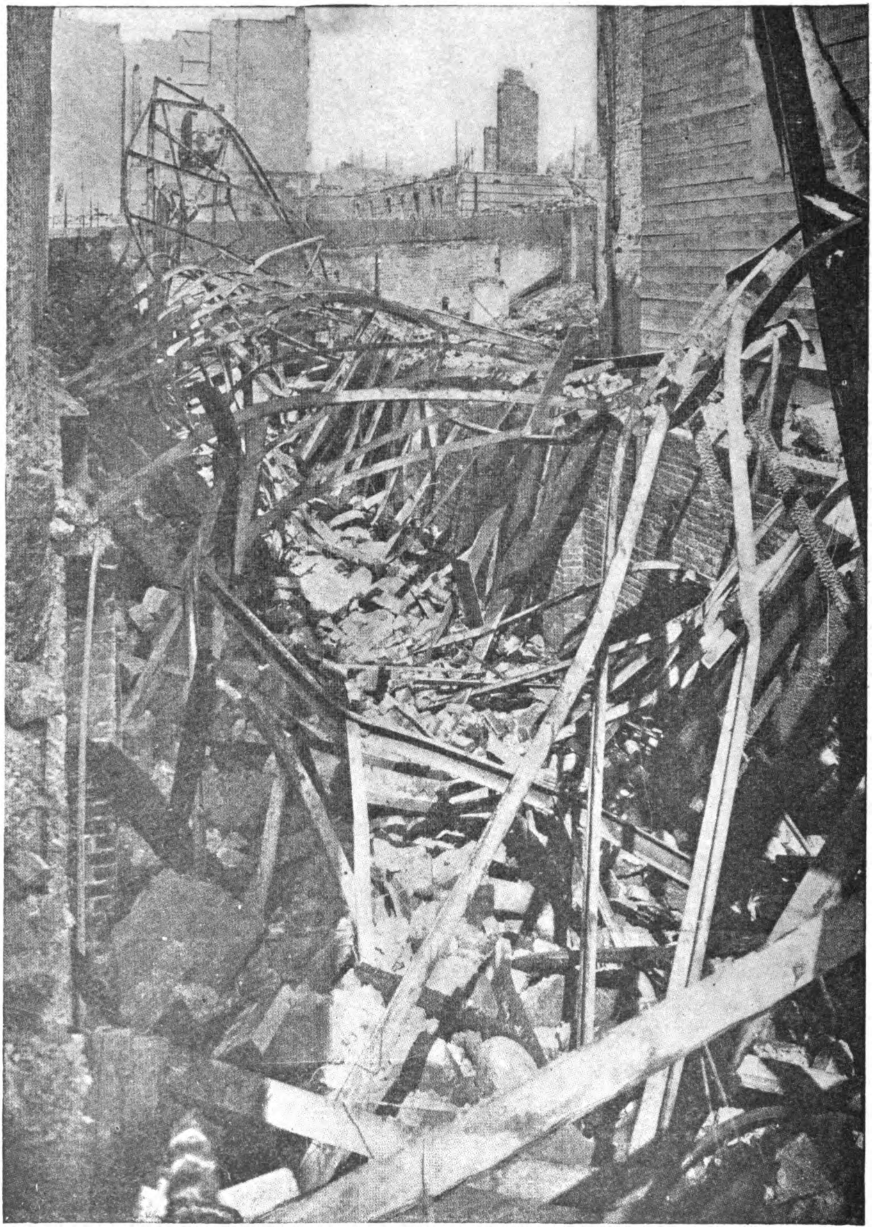


Fig. 8. What was Left of One of San Francisco's Reinforced Concrete Buildings After the Fire
Note the unburned wood in the debris

average cost of fighting vermin amounts to $\frac{3}{16}$ of 1 per cent of the cost of the buildings, per annum.

Fireproofing a building eliminates this feature. Figure up these comparisons and then note that a thoroughly fireproof building, in its first cost, will rarely exceed the outlay for ordinary constructon by more than 10 per cent. In stores and warehouses this difference is reduced to 5 and 6 per cent, while in some localities, I have found that there is barely an appreciable difference in cost between fireproof and non-fireproof construction. In at least three recent cases, to my certain knowledge, bids taken on both styles of construction have developed an actually lower figure for fireproof construction than for wood.

NOTE. Of course, there is always an element of chance in taking bids and there is wide room for such differences, a fact which will be realized when I say that on a building that actually cost $200,000, for instance, and with all contractors figuring on the same basis, there will frequently be as much as $80,000 difference between the highest and the lowest bids.

Thirty years ago, when steel and tile were first used in construction, and when wood was cheap, the cost of fireproof construction was prohibitive except in special cases. People were so informed, and they still hold that idea, and I am afraid that it is going to take some years, and many more fires, and other hard lessons to get this idea out of their heads. They would like their buildings to be fireproof, well enough, especially after a big fire, but the wish dies a painful, though not a very lingering, death under the influence of the idea that it is going to cost them so much more money. A conflagration is but a chance after all, and the cost of fireproofing, they think, is a certainty, hence their deduction that it is not sound business to balance a certainty of cost against a purely problematical advantage.

Ignorance Retards Spread of Fireproof Methods. It is rather distressing that in the very places that have been most recently singed, the rebuilding is largely upon the old lines of tinder-box construction. One reason is that people do not know any better and the next is that those who ought to keep them posted fail in their task. I have a report of one city, an enterprising city of the Middle West, where 2,677 permits were taken out last year, involving an outlay of $6,600,000, and where there were but three fireproof buildings erected

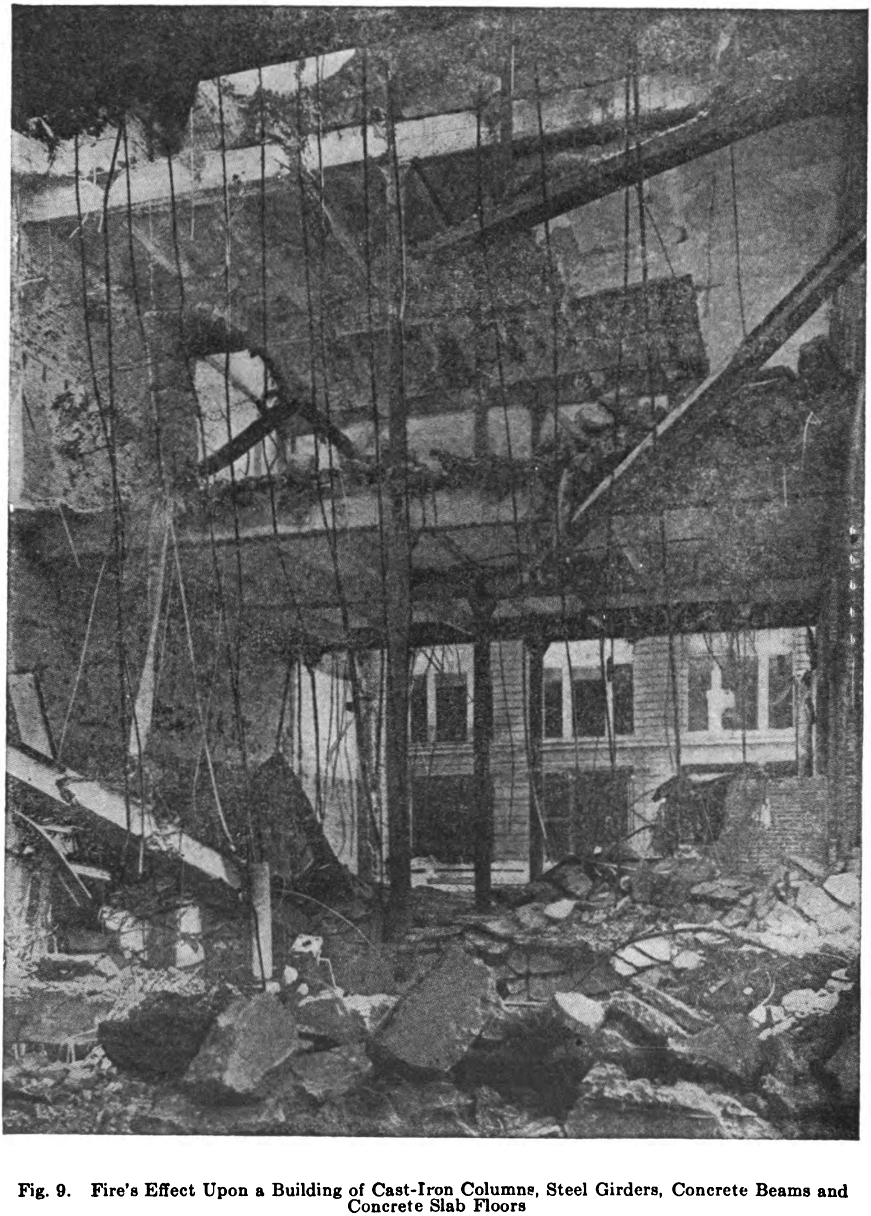


Fig. 9. Fire's Effect Upon a Building of Cast-Iron Columns, Steel Girders, Concrete Beams and Concrete Slab Floors

during that period. Incidentally, the fire losses amounted to over $1,000,000. In another city $15,400,000 was put into 2,002 buildings, of which number 4 (!) were fireproof. In still another city where

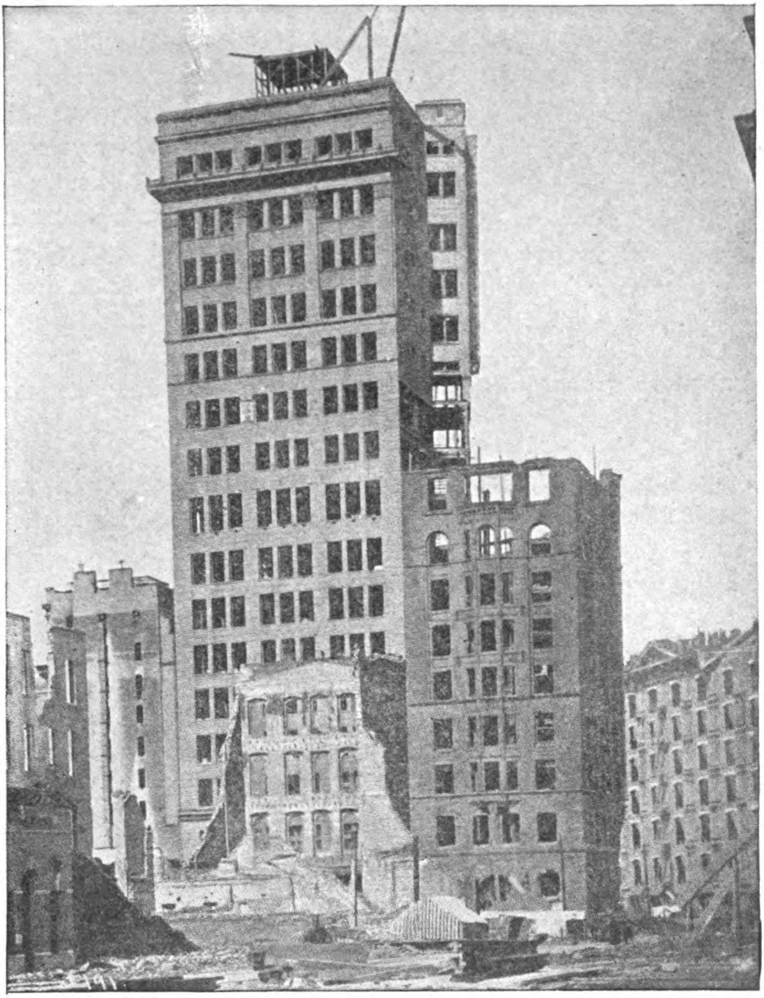


Fig. 10. The Almost Completed Chronicle Building in the San Francisco Fire
Nothing in it to burn but a little scaffolding so that it was virtually uninjured

4,666 permits were taken out for buildings involving nearly $8,000,000, but 22 buildings, mostly small ones at that, were fireproof, and the fire loss was $1,500,000.

I blame the newspapers very largely for the apathy of the people upon this subject. If a dog goes mad and bites a man or two the newspapers clamor for more ample police protection, the proper licensing of canines, if not their elimination from civic privileges, and a host of other cures and redressive measures without end; after a terrible railroad wreck the same papers clamor for the abolition of grade crossings, the providing of more perfect block systems, etc., but after a great fire they simply clamor for greater water pressure, a larger fire department with better apparatus, feeling about, as it were, for some sort of palliative, or at best a little salve to soothe the wound, rather than striking at the root of the evil and eradicating it by advocating a preventive. We have been able, by using drastic methods, to thoroughly stamp out smallpox, yellow fever, and many of those things which seemed a few years ago to be the necessary accompaniments of life in certain districts. This was not done, however, by curing the patients so afflicted, but by wiping out the cause, thus preventing people from contracting the loathsome diseases. If, now, the newspapers of the country would set themselves just as energetically to the task of advocating fireproof construction and perfected fire-fighting appliances, insisting upon the proper legislative enactments, it would be but a question of months when popular opinion, so directed and educated, would place insurmountable obstacles in the way of the speculative builders of fire traps, and there would be evolved some method of eliminating the danger, which lies in existing buildings, of antiquated construction.

WHAT IS FIREFPROOF BUILDING?

"Fireproof building" is a much misunderstood term.

Buildings are constructed for certain specific purposes. No matter what kind of building may be under consideration, it is built for one of the following reasons:

1. The protection of persons from the elements.
2. The protection of property from the elements.

From these two basic principles follow all the multitude of variations in buildings, variations of arrangement which provide for the comfort and convenience of persons sheltered by the buildings, and for the convenient use of property stored in the buildings.

VIEW OF THE OFFICE OF A UNIQUE FIREPROOF HOTEL
Steel and Tile Construction, Concrete and Terra Cotta Finishing Predominate
(*Architect, Frank Lloyd Wright*)

The dwelling, apartment house, hotel, hospital, theater, etc., are primarily for the protection and comfort of human inmates; secondarily for ministration to their convenience, pleasures, and ethical conditions of life, which are provided for by the installation in the building of suitable property, that is to say, the building's arrangements and its contents. The warehouse, museum, store building, etc., are designed chiefly for protection to property and the use of property.

The destructive elements of nature against which all buildings must provide are *wind, water,* and *fire.* Human skill solved the problems of protection against wind and water centuries ago, in a more or less practical manner; of course, improvement has constantly increased the efficiency of originally cruder methods.

It has remained for modern science to solve the difficulty of protection against fire, particularly under the congested conditions of life today, and it is this evolution which has led up to the creation of what is known as the modern fireproof building.

Popular Misconceptions. *Noncombustible Material.* The chief misunderstanding that occurs in regard to the term "fireproof" as applied to buildings, is largely due to the fact that most people consider as "fireproof" (not subject to destruction by fire) materials which are simply noncombustible. In other words, many people think that a material which *will not blaze* is a fireproof material, overlooking the fact that the destructive element of fire is not alone in the blaze, but in the *heat.*

Unprotected Iron and steel. Another misconception is due to the failure to distinguish between the parts of the building which are fireproof, and the parts which are not fireproof. Half a century ago there was a great wave of building activity in the use of a construction of unprotected cast iron, this material being then considered a fireproof material. Iron will soften under a comparatively low volume of heat, and in this softened condition will collapse of its own weight. How much more disastrously will it be injured when weighted down with floors and the contents of the building! It was the collapse of a number of these buildings during fires, which led to modern fireproof construction.

The same fallacious idea was held regarding unprotected steel, and these fallacies are still exceedingly strong in the mind of the uninformed person who has given the matter only casual consideration.

All kinds of stone, marble, artificial stone, plaster, cement, and

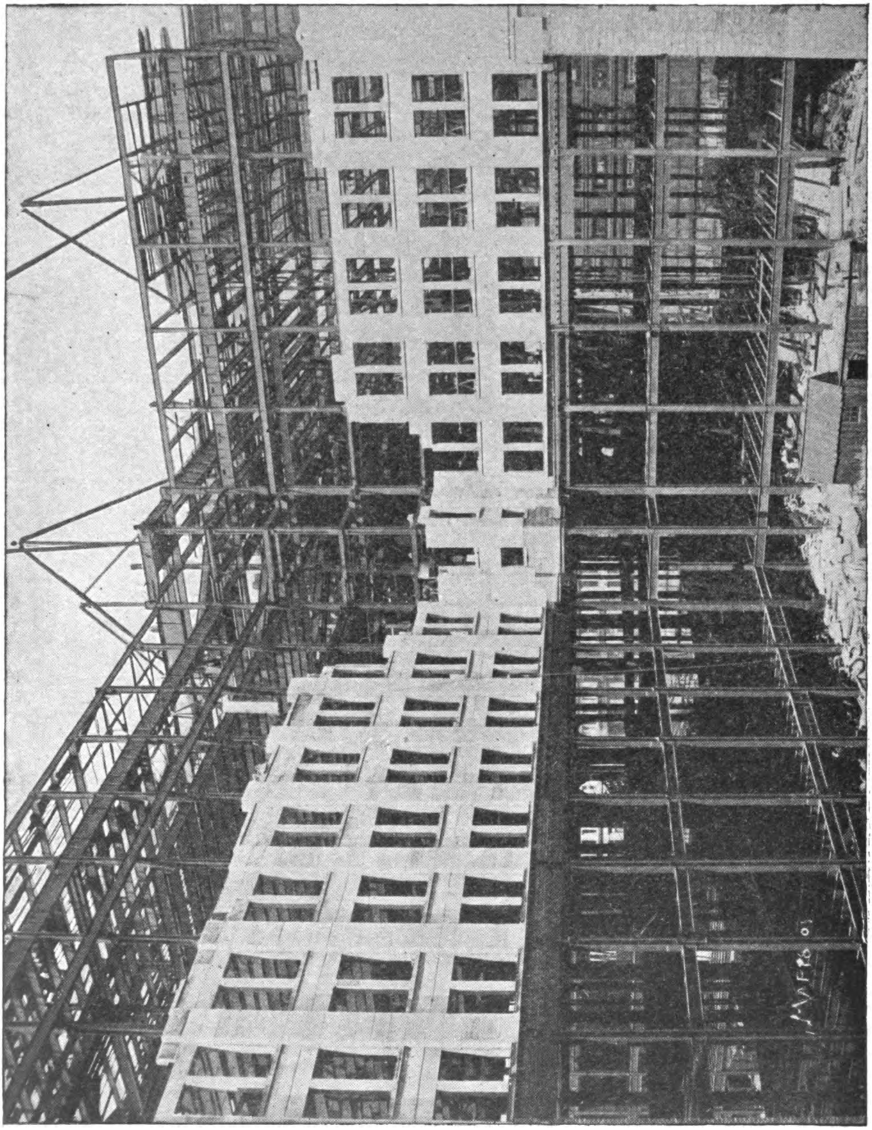


Fig. 11. The Partially Completed Steel Frame of the Chicago Post Office
One of the most fire-resisting and perfectly fire-proofed buildings ever erected

metals, are considered by the uninformed as fireproof, yet the action of heat on these will cause them to crack, split, crumble, bend,

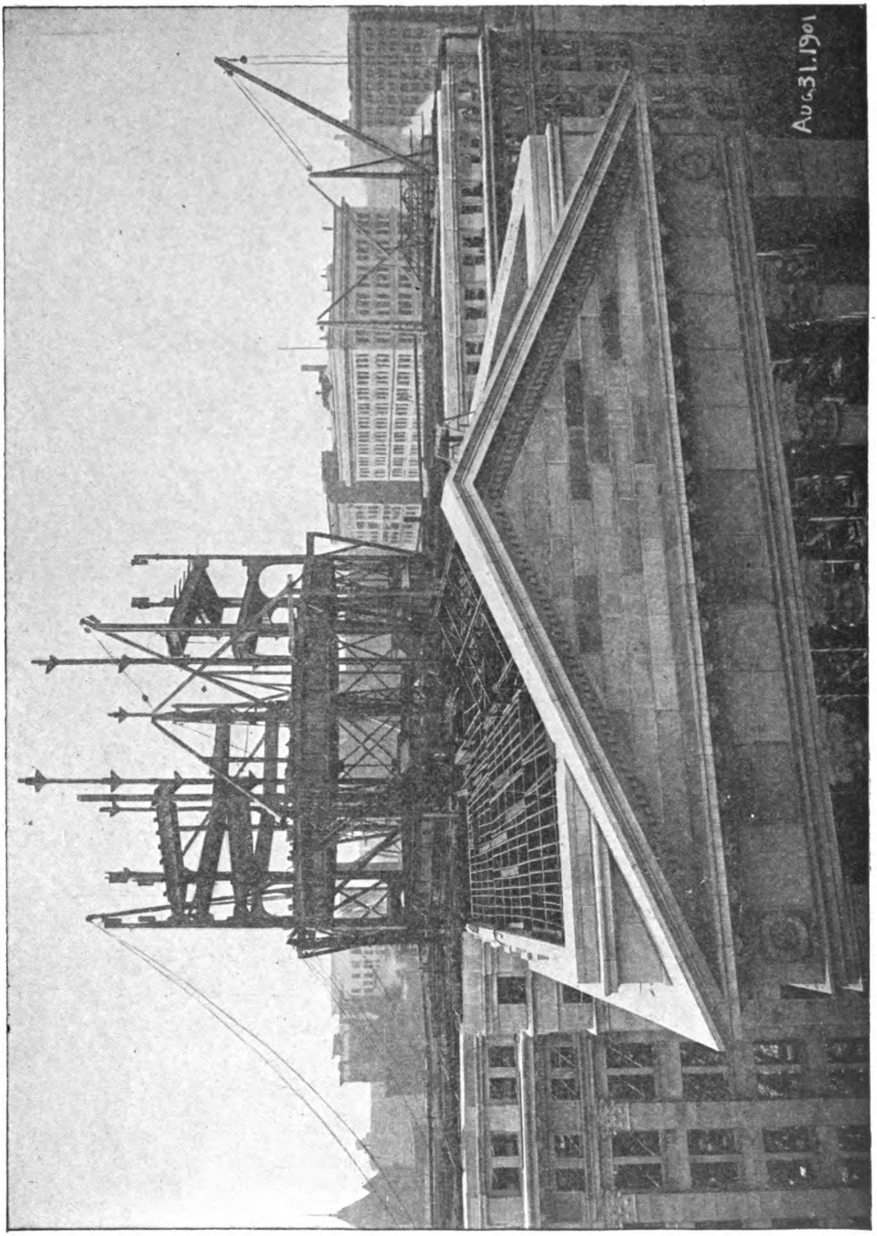


Fig. 12. The Beginning of the Dome of the Chicago Post Office
All the outer walls here seen are granite. The danger from fire is remote. The cross shaped wings expose but little of the building to fire in the buildings opposite

warp, and disintegrate in varying degrees, in some cases absolutely ruining their efficiency for building purposes, as has been demonstrated in actual fires and under tests again and again.

Contents and Finish of Buildings. Under practical conditions at the present day there is considerable confusion as to fireproof buildings, on account of the failure to make the distinction between the building itself and its contents, *i. e.*, the property which it was built to protect. This confusion can best be illusratted by citing the fact that if you build a solid masonary vault of brick, or terra cotta hollow tile, or concrete, fill it with combustible goods, such as books and papers, or furniture, you will at once perceive that if you set fire to these *contents* they will readily be destroyed, while the vault itself will be entirely unharmed, or but negligibly damaged.

Carrying this illustration further, if you build in one side of this vault a window with wooden sash and hemp sash cords, fit the vault inside with a wooden base-board, and cover the bottom of the vault with a wooden floor, a fire will unquestionably destroy, at the same time with the contents, the window, the sash and the base-board and floor, leaving the vault itself intact.

This illustrates the relation between a fireproof *building* and its *contents* and *finish*. The building structure itself, its columns, beams, girders, floors, walls and partitions, may be thoroughly fireproof, and, therefore, similar in efficiency against fire to the masonary vault. On the other hand the contents of the building, consisting of carpets, curtains, furniture, books, etc., with all such details as wood finish in the shape of windows, doors, marble finish in corridors, statuary, unprotected stair railings of iron and bronze, etc., would be entirely destroyed. That is to say, all parts of the building which were made fireproof and which could possibly be claimed to be fireproof would be intact and undamaged. Everything else in the building might be destroyed.

Division of Building into Isolated Units. This leads to the correct method of fireproof building under modern conditions, involving that great basic principle of protection of buildings against fire, viz, *the principle of complete isolation.*

Suppose you wanted to erect a six-story fireproof building, but instead, having plenty of land upon which to spread out, you put up six one-story buildings, each separated from the other with thoroughly fireproof walls and partitions. Fill your six buildings with combustible contents, start a fire in one and let it burn itself

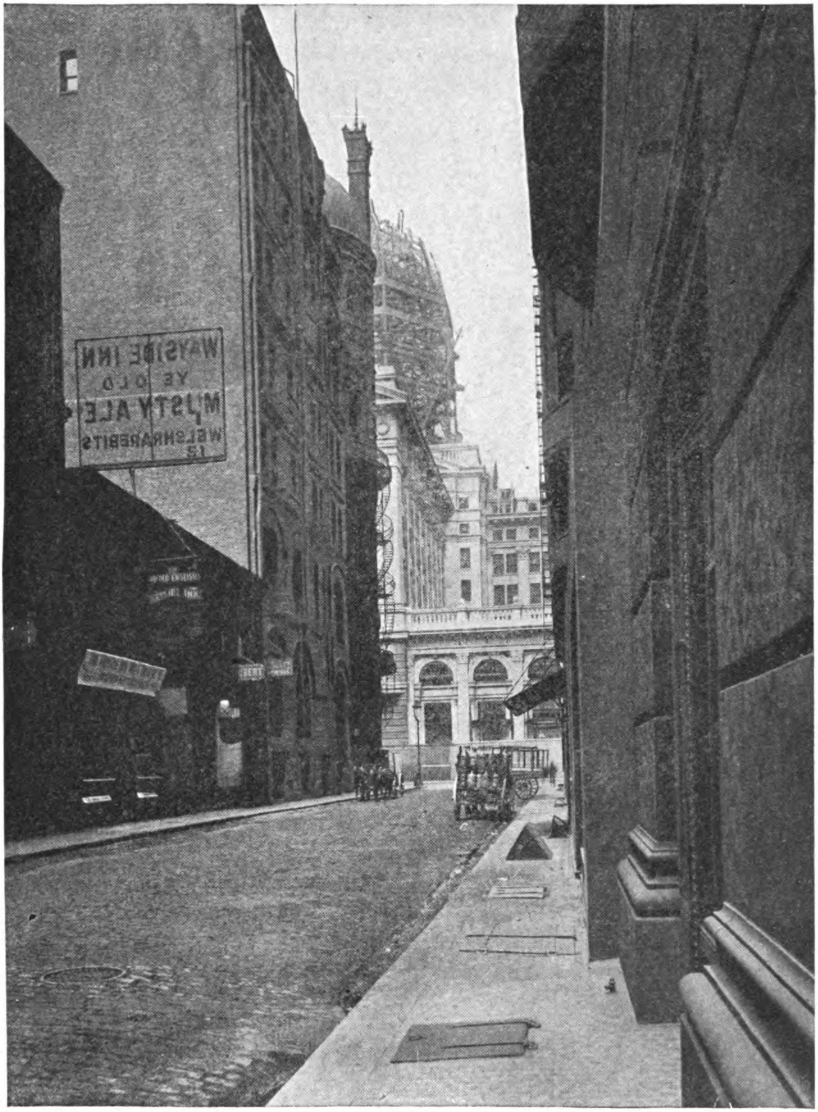


Fig. 13. A Vista of the Chicago Post Office Down One of Chicago's Narrow Streets

out. Your five other buildings will not be endangered, harmed, or damaged. The contents of the building fired will be destroyed,

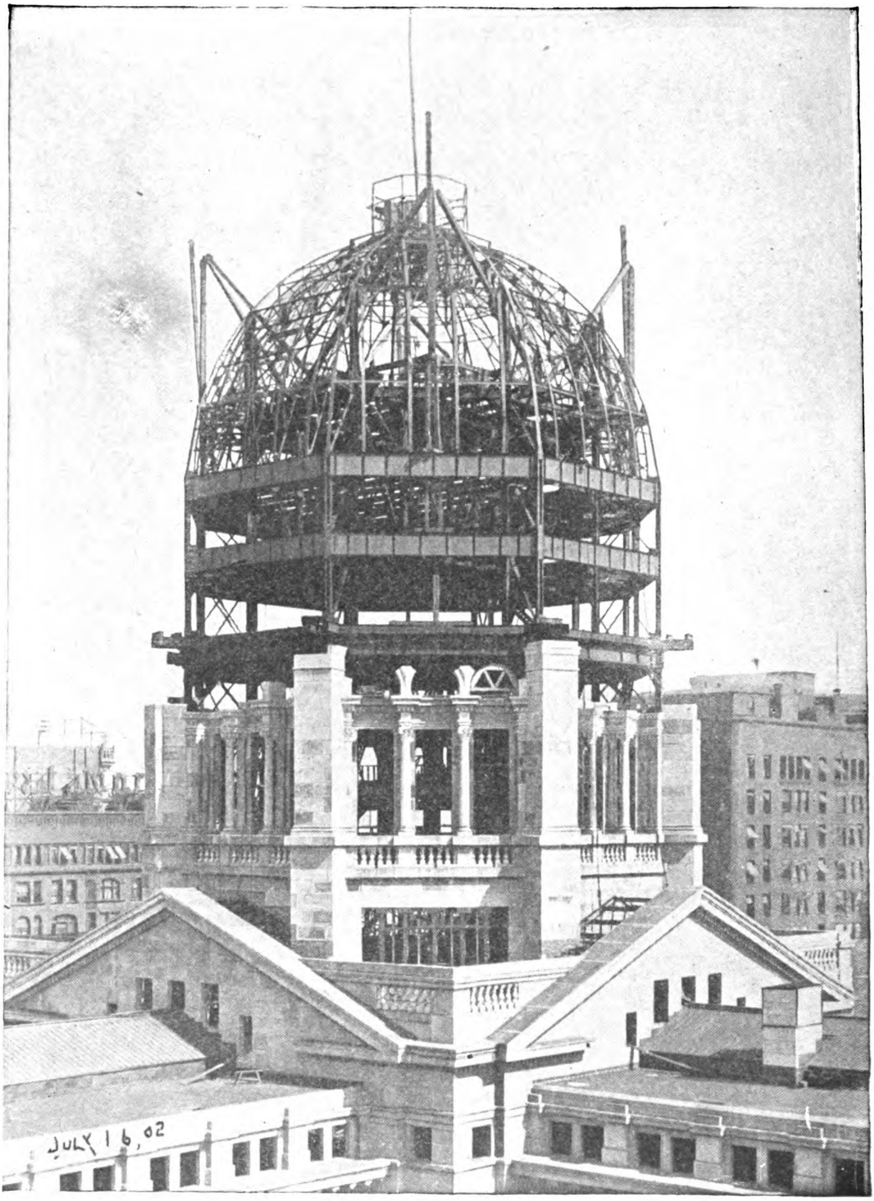


Fig. 14. Putting up the Last of the 19,000,000 Pounds of Steel Framing in the Chicago Post Office
This building is one of the very best, if not *the* best specimen of steel frame and tile fireproofing in the country

but the building itself stands intact and with slight repairs is again ready for occupancy.

Now assemble your six buildings on one site in six unconnected stories with your floors as well as your partitions fireproof. If a fire is started in the contents on one floor, the principle of isolation protects the contents on the other five floors just as it does in the six separate buildings. Assume that in your six one-story buildings you had left combustible doors opening from one building into another. Is it not evident that the fire would have swept from one to the other and destroyed the contents of all six, no matter how fireproof the structures themselves were?

Suppose in your six-story building you leave openings of combustible material, combustible doors in partitions of the same floor, combustible open elevator shafts, machinery shafts, air vents, etc., will not the result be the same as in the six single buildings, communicating through combustible entrances?

The most highly perfected and most familiar type of the strictly fireproof building is the commercial and office building seen chiefly in our larger cities, and commonly called the "skyscraper". These buildings are simply steel frames, upon the outer columns and girders of which are carried the outside walls, while on the interior columns and girders and beams, are carried the floors and roof. The same material which protects the steel skeleton from the action of fire, namely the terra cotta hollow tile or brick or concrete in sufficient mass, is also set between the spans from beam to beam, thus forming the floors.

In the ideal building, from the standpoint of fire protection, there would be no openings such as elevator shafts, stairways, skylight wells, etc., through these floors. Even if such were the case, it is readily to be seen that the steel would be entirely protected with a material which is absolutely proof against destruction by fire and which is a non-conductor of heat, thus preventing the heat from attacking the steel. The building in its entirety would, therefore, not only be safe against destruction by fire, but if a fire started in the contents placed on any floor, the floors above and below being also of this fireproof material would prevent the fire from going through the building, thus isolating it, limiting it to the floor on which the fire had its start.

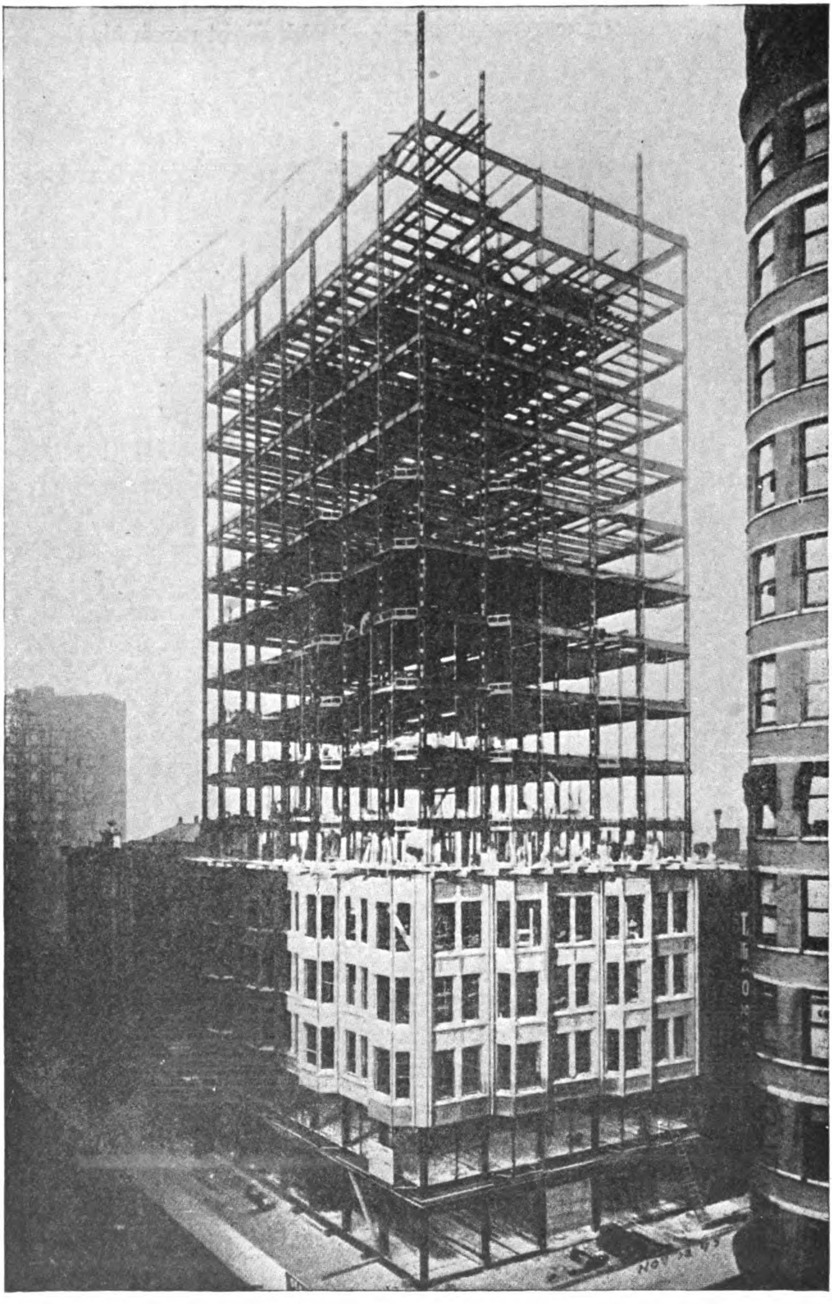


Fig. 15. The Fisher Building, Chicago, a Record Breaker in Speed of Steel and Tile Construction Thirty days above street level

Necessity for practical use of the building, however, requires that there be some means of communication and passage from one floor to the other, which necessitates the cutting of elevator shafts and stairways. Under the best practice in fireproof buildings these means of communication are cut off by various methods, the best of which is an enclosing wall of terra cotta hollow tile or brick around the elevator shafts and around the stair openings.

The rapid destruction of combustible finish in fireproof buildings may be traced to the lack of these precautionary measures in completely isolating each floor from the others. Elevator shafts, stair openings, and openings for belt shafts, electric wires, pipes, etc., are the most common causes of communication of fire from one part of an otherwise fireproof building, to the connecting part, thus giving the fire free opportunity to attack the contents of the building throughout all its floors. Care in the designing of the buildings and the use of proper safeguards for all the openings, will absolutely eliminate this feature.

The smaller each open area is, the less damage can be done to the contents by fire. If the size of each area is limited only by the size of each story, there is, of course, nothing to prevent the fire sweeping all through the story on which the fire originates. If the area of each floor be cut in two by a fireproof partition the possible damage will, of course, be reduced by half.

After the floors are laid, the area of each floor may be and usually is—depending on the use and size of the building—cut into smaller areas by the aid of brick, terra cotta hollow tile, concrete or metal lath and plaster, built in the shape of partitions, forming dividing walls for rooms, offices, hall-ways, etc.

In addition to this ideal type of fireproof construction, there is an infinite variety of other constructions which depend, of course, upon the size of the building, the uses to which it is put, the loads which the floor construction is to carry, and the architectural appearance of the building.

Steel and Tile or Concrete Frame. The first step in fireproof construction was undoubtedly taken with the invention of the elevator, which gave a means of rapid communication between stories and allowed the buildings to run higher than it had been customary to build. The tall building soon showed the necessity for other construction than heavy supporting walls and wood framing, which necessity coupled with American ingenuity gave us the skeleton steel frame and the hollow fireproofing tile to encase it. Little by little the system was perfected and no man ever dreams today of erecting a high building by the old methods; he uses the steel frame and tiles or some one of the later substitute systems of reinforced concrete. Even should he desire to revert to the manners of his

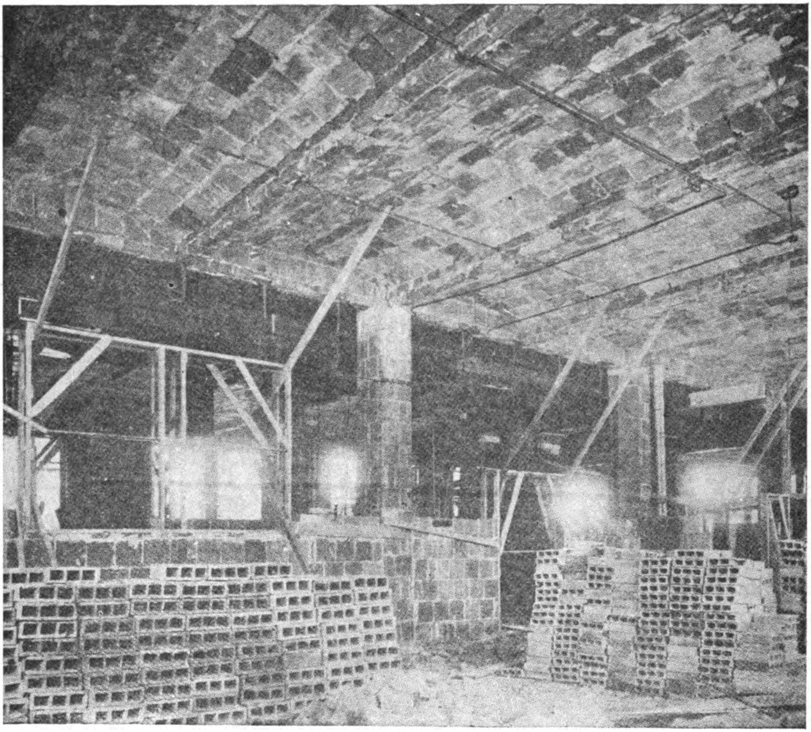


Fig. 16. Fireproofing the Great Chicago Court House Building

fathers, the law has progressed enough, in its recognition of its duty to protect the community, even at the curtailment of what have been deemed "private rights," to prevent him. The result has been that where the proper intelligence has been used in assembling the parts of these structures even the fiercest conflagration has left but comparatively light scars upon them. People have seen this and the thoughtful have wondered. Since the vitals, the skeleton of a building, remained uninjured in any such test, why could not the rest of the building also be rendered immune?

Wire Glass, Metal Doors, and Other Protective Features. Theory and observation have established a standard for the whole building in all its parts. It has been decreed that the units of space shall be comparatively small and that each unit shall be so constructed as to become virtually a separate building; external openings are to be protected with wire glass in metallic frames or such sash, automatically

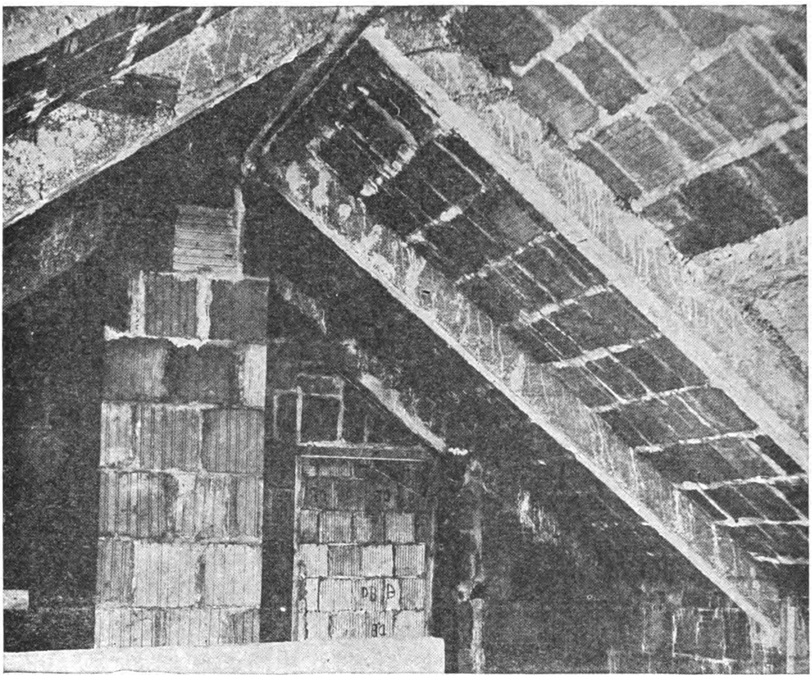


Fig. 17. Showing Concrete Beams and Tile Slabs of Fireproof Roof

closing at a certain temperature and glazed with two thicknesses of wire glass and having supplementary shutters in particularly exposed places. The roof has been recognized as a vulnerable point, it formerly being frequently of wood even in so-called fireproof buildings; today it must be as substantially built and protected and as incombustible as any of the floors. It has been demonstrated that wooden doors and interior finish are frequently the means of communicating fire from one unit of space to the other; all this finish should now be of some incombustible material. There are metal doors on the market, there is an asbestos board, and even wood properly plumbagoed and metal-plated is a strong resistant. Fire after fire has proved that however stoutly floors may be constructed, if they are riddled full of holes and well-shafts, fire is going to communicate from one story to another; and the higher the building, the greater the rate of speed and the force with which it travels upward—the principle of the chimney—spreading ruin and devastation in its wake. So sensible people enclose their stairways and elevator shafts.

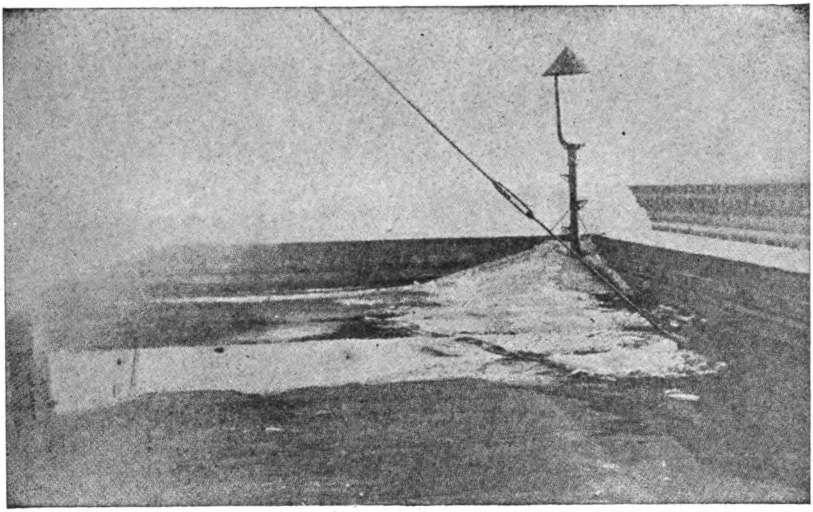


Fig 18. This Photograph Shows Unmelted Snow on a Tile Roof After a Three-Hour Fire in the Story Below

THE "CITY UNBURNABLE" A POSSIBILITY

There is nothing unknown, mysterious, or extraordinary about the operation of fire. The science of fire prevention, likewise, is not occult or even wonderfully difficult to learn and apply. With what we have at hand it is easily possible to erect an absolutely fireproof structure that will not only resist fire, as far as total annihilation is concerned, but that cannot be damaged more than 5 or 6 per cent of its cost value by the fiercest conflagration possible to imagine. Nor would such a building be prohibitive in initial cost, indeed, not be over 6 or 7 per cent more than that of the imperfectly fireproof building, and in the course of a very few years, by reason of the lessened insurance premiums or none at all, freedom from repairs, etc., the cost would be less than that of the other building; ultimately its permanency and absolute immunity from fire would render the cost of fireproofing an incomparable economy. It is the only sane thing to do and something that our people will eventually realize as the easiest and best mode of construction for the home as well as the factory, church, office, school or state capitol—*everything.*

Paradoxical as it may seem, *the more fireproof the buildings are built the less absolutely fireproof need they be.* Today, as has been remarked, when we build something we are anxious to render invulnerable, we have to take extraordinary precautions because of the conflagration-hazard, the combustibility of so many of the surrounding structures. Imagine a city of absolutely incombustible construction and you can readily see that none of those buildings need be as fireproof as we have now to build. There being nothing to burn, no such extraordinary measures need be taken against fire. This condition exists very largely in European cities; how strangely short-sighted we have been, not to recognize such advantages long ago.

Little by little, yet rapidly when one realizes what obstacles have been in the way, our municipalities have recognized that the individual cannot always be depended upon to do the right thing and even our architects cannot always be depended upon to advise the right things; they have, therefore, in many places made obligatory the essentials of good construction, of fire prevention. One by one preventive legislative acts are enacted and passed, and one by one fire preventive means are forced upon the attention of the people, who finally discover that these means are effective and not costly. All the signs are most hopeful and it is only a question of time—let us be optimistic and say a little while at that—when it will be as natural for a man to insist upon every part of his building being well done as it is now for him to direct that the structural portions be fireproof. The "*City Unburnable*" is no idle dream of a visionary theorist, but a possibility whose realization is near at hand. (What do twenty years amount to in the life of a city or a nation?)

Municipal Building Regulations. Hundreds of cities are now

Fig. 19. The Largest Office Building in the World—The Hudson Terminal, New York City
Well fireproofed but a bad exposure in that it is surrounded by a miserable lot of fire-traps

revising their building regulations, writing new ones, or have just put amended ones into force. This is well, for it shows that the great fires of the past few years have not been wholly unfruitful lessons. Perfect building is absolute economy; good construction is sensible and shoddy construction is positive extravagance—that basic fact must be remembered in devising regulations. A city full of good buildings means lessened maintenance cost for each owner, fewer repairs, a longer life for the buildings—and in consequence lower rents—much less expense for fire departments and water protection, the very minimum of insurance rates and premiums, and the maximum of safety to life and property. It means millions upon millions of dollars saved and a great municipal problem solved.

It is evident, therefore, that the responsibility rests with our building departments to fight valiantly for the most stringent building regulations, for in that way only, lies safety and real progress for our cities. A first-class city can be an aggregation of only first-class buildings. Therefore, in the congested districts, at least, only perfect construction can be tolerated—the complete and total elimination of the combustible in building materials.

Fire Limits. Many people clamor for restricted fire limits; the building departments should clamor for as *wide* limits as possible. That is a wise provision, real conservatism, for it is only a question of a few years when the existing fire limits of any city must be extended, thus taking in all the second-class buildings permitted under the old regulations. These old ones endanger the new buildings, which, as a consequence, must be superlatively well built to withstand the adjacent fires that are sure to rage all about them in the old buildings. We must all realize that with as rapidly growing a population as ours, the town of today is the city of tomorrow. Every one of our cities is now suffering from an inheritance of fire-traps handed down by previous generations. The city that would make its fire limits comprehend *the whole* of its corporate area would indeed be a sensible city, a real first-class city. But it is hardly to be expected that any one of them would show that much foresight all at once; therefore it is up to the building departments to get the next best thing by having the fire limits—the area of first-class buildings—take in just as much territory as possible.

Inspection. A building inspector requires courage to make

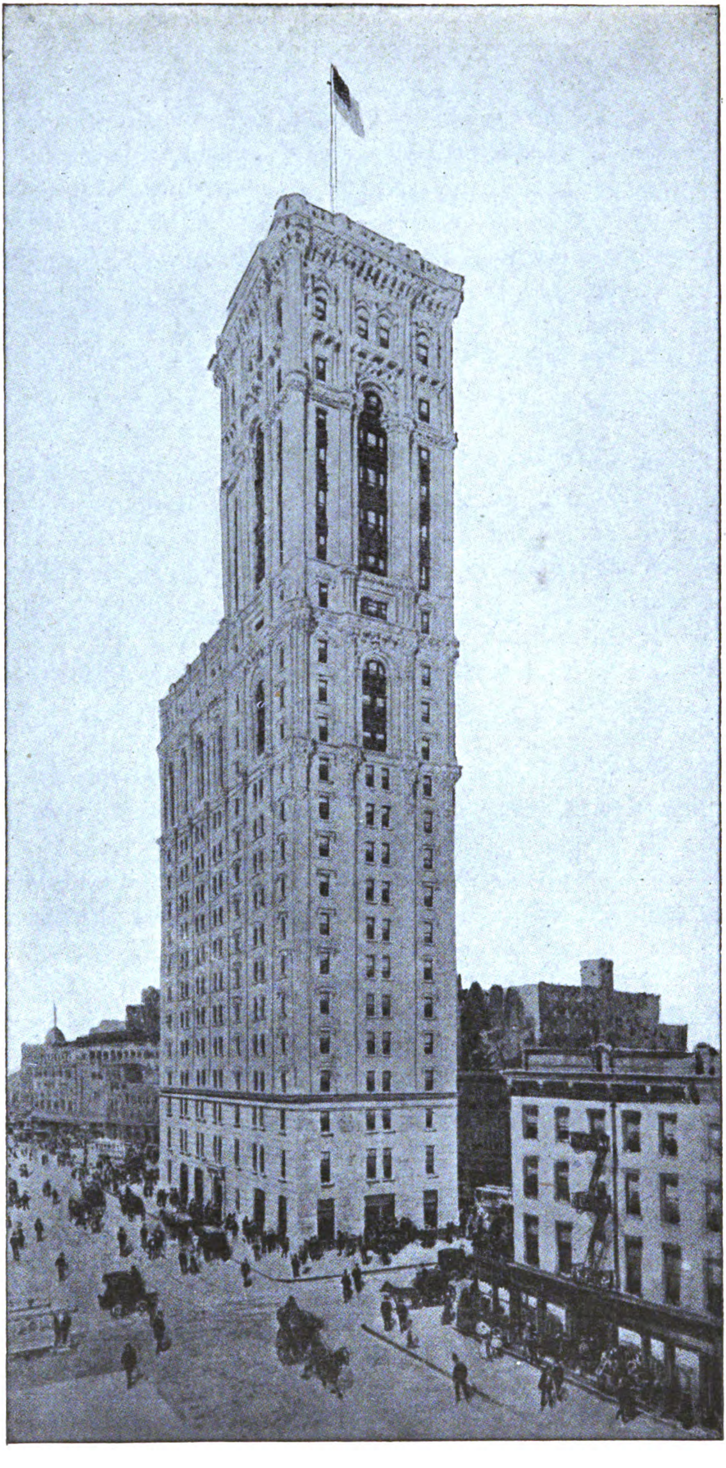


Fig. 20. "The New York Times" Tower. A fine type of office building

a good fight for better construction and enlarged fire limits. He is opposed always by the builders of cheap houses—the only men who really profit by tinder-box construction—and these men are generally pretty strong politically. I know of three cases where progressive, public-spirited, and capable building inspectors were ousted from office by the political manipulations of such builders and of certain real estate dealers who felt that the inspectors were too "active" and were hurting their business—that of selling flimsy houses to workmen. Another inspector was elected upon the explicit promise not to tamper with the existing building code that permitted such construction; while still another, having started a revision of his code, was calmly informed by his mayor that when his revision was completed and ready for passage his "job" would be at an end! The man not being a "hero" has protracted that revision already three years.

Everywhere a strenuous effort is being made by these same cheap builders to have the building codes revised "downward." They are the self-constituted defenders of the poor man's rights and in that capacity clamor for the cheaply built house, the "modest home of the laborer". That cheap house is not only a menace to the whole city but is the very dearest and rankest extravagance the poor man can indulge in. Only the rich can really afford a fire-trap, for its deterioration and destruction will not affect them materially, and yet it is the rich who build permanent, fireproof homes, while the man in ordinary circumstances, with whom every dollar counts, is the one who invests recklessly in something that any day may mean a total loss to him—a home that initially costs almost as much as a well-built one and which is deteriorating at a most rapid rate.

The following paragraph, which gives the gist of the remarks of a judge in a recent court decision in Washington, will best illustrate what that deterioration means:

A man bought a house from a speculative builder, one of these houses showily painted externally and with nickel plumbing and white tiled bathrooms that so allure the home seeker—the well-baited hook offered by Mr. Wholesale Builder. After living in it three months, the roof began to leak like a sieve, the foundations, walls, and cellar floors cracked and crumbled (the concrete was but a little cement daubed over some stone and much dirt), the plastering cracked, the furnace was insufficient to heat the house, every flue leaked, and the beautiful nickel plumbing failed to work. Feeling defrauded and outraged the man sued the builder to make him correct those

Fig. 21. The Great Metropolitan Life Building Tower, New York City

wrongs and put the house in habitable condition. The court listened and pondered and finally ruled that *all* those speculatively-built houses were put together in a slovenly manner, were liable to fall to pieces, to burn, or anything else; that this was the regular way of building those "for sale" houses, everyone knew it, and the man was therefore not an "innocent" purchaser in the eyes of the law. Such houses could not reasonably be expected to last in first-class shape for over three months and since he had been in the house that time he had gotten his money's worth. The suit was, therefore, dismissed.

So legally, at least in Washington, if a speculatively-built house stands three months it has completely fulfilled its mission. Three months!

Attitude of Architects. It has been deplored that the architects give small encouragement to the fire-protection movement. Too frequently have they obeyed their client's foolish behests and done all in their power to get by any means the "privilege" of building less resistingly, more "cheaply," than the law permitted. However, the profession as a whole is now showing more intelligent interest in the effort to lessen fire's havoc; our architects preach fireproof construction, urge it, and insist upon it; they advocate city planning so that fire dangers may be minimized; they do more in the fire prevention line than the law obliges, and it is seemly that they should, for they ought to know more about building than any one else.

An extract or two from a recent address by President Irving K. Pond, of the American Institute of Architects, will indicate the present broadened view of the real function of a building:

The changing conditions of everyday life act as destructive agents, so that the economic loss in the demolition of the present to prepare the ground for the future, is as appalling in a way as is the destruction by any of the natural causes. The philosophic attitude to maintain toward the whole subject is, that out of each great loss must come some gain, and that no great good is attained without the payment of an adequate price. And so considering the matter of permanent building and protection against the elements, we are brought face to face with the modern problem which is taxing the ingenuity and genius of our architects and economists—the problem of city planning for the present and the future.

The value of building for permanency is to be considered carefully where conditions are ever shifting, and buildings to serve the special purpose of today may not meet the requirements of tomorrow. The logic of city planning must appear as keen as the logic of house planning, and the distorting of the function of one part of the city must appear just as chaotic and as fatal to economic order as the derangement of the functions of various rooms in the dwelling. The furnace room should be equipped to receive the furnace and fuel and calls for certain protection which need not be afforded to other portions of the house. To erect the furnace in the drawing-room or to install the range in the boudoir is to derange the life of the household and stultify the meaning and design of the house and to presage a lapse into barbarism or to indicate a non-emergence from that estate; and thus is indicated the possible connection between city planning and logical construction and necessary

Fig. 22. The Fireproof Brooklyn Tabernacle
A combined church and skyscraper, offices, etc.

protection. The logical planning of the city—the laying down of permanent lines of development, the laying out of permanent avenues, of inter-communication and lines of transportation, in order that the functions of the various portions of the city shall not be deranged, but shall be susceptible of logical and rational growth and development—bears directly on the matter of comparative stability of construction. The wisdom in creating city planning commissions and even in applying the theory to smaller districts becomes apparent and should be emulated in our own country by our legislative bodies, and warrant of law rather than individual initiative should bring about the desired results. The idea which has been in practice and has justified its existence for a long time in Austria is coming into vogue in Germany, and is just now being adopted in England. Various of our American cities are attacking the problems from some special point of view individual to the locality, but the wider problem in all its manifold bearings on social organism, industrialism, housing sanitation, morals, and beauty has as yet to be conceived by the general body of American city planners. When our civilization is established and we cease to be a restless body pushing forever toward the frontier, our cities will partake more of the nature of fixed abiding places and less of the nature of the camp, as our residences of today are smacking more of the permanency of buildings and less of the ephemeralism of the tent. At such time sanely-conceived city centers will be established, calling for permanent structures suited to the needs of the locality, and connected with other similar centers by great arteries of inter-communication, which themselves will be of permanent and lasting nature. The industrial quarters, the resident quarters, the wholesale quarters, will be distinctly differentiated as are the apartments of a logically-designed dwelling and will be susceptible of logical and predetermined growth. When the laws of economics shall have been understood, when each man's duty to his neighbor and to the community shall be as thoroughly recognized as are the rights he arrogates to himself, when the laws of order and the love of beauty shall have been established in the heart of the race, the over-topping commercial structure in the center of other commercial structures or in the center of the resident district will be a thing of the past. In fact, in the logical city, over-topping commercial structures will not, as now, add their disfigurement and their problems of transportation and of sanitation to the neighborhood they infest, and the matter of protective construction and protective appliances will be simplified.

Passing now to the relationship of construction and protection to city planning and coming down to first principles, perhaps the most effective method of protection, as it affects the community generally, would lie in the operation of a law making the loss or damage to extraneous property or to life to hold against the owner of the property from which the fire spreads or the damage emanates. (Our "neighboring risk" theory.) If the title to such property were vitiated until claims had been settled, there would be less argument as to the desirability of protection in specific cases, and there would be smaller need to penalize neighboring buildings of a higher type.

The high-class building should be protected against the lower class building by equitable legislation and the lower class building should not be allowed to jeopardize the entire neighborhood as well as itself. At the same time the higher type of building, especially when it runs into an inordinately high structure, should not be permitted to jeopardize the safety of life and limb within its own confines. This entire subject impinges on that of city planning and the local distribution of various types and industries and commercial activities.

WEST ELEVATION OF MUNICIPAL OFFICE BUILDING FOR THE CITY OF NEW YORK FROM ARCHITECT'S DRAWING

McKim, Mead and White, Architects, New York

Ground Floor Plan Shown on Page 428

FIREPROOF CONSTRUCTION

PART II

OUR NATIONAL PROGRESS

EVOLUTION OF BUILDING CONSTRUCTION

Early Forms. Our forefathers, the first settlers, when they landed on these shores, made themselves rude huts to live in, wooden shanties and "camps" and stockades to protect themselves from the Indians. Cabins and cottages succeeded these shanties, but these, too, were of wood. Then some of the more pretentious "mansions" were built of brick brought from England or Holland by the ships which came here so ballasted and with package freight to carry back the heavier cargoes of grain and the other products of the new land, although only a few such buildings were built.

Colonial. It was proper to have stone trimmings in combination with those imported bricks or the home-made article—for it was not long before they began to bake their own brick, which was a crude product at first, but rapidly improved until it was as good as or better than anything they could import—but stone, either the imported or that quarried in our own hills, cost much money, so they imitated stone work in wood, painted it, and by and by, sanded it to look as much like stone as possible. In design they made their buildings to look as much like the old be-columned and porticoed, stately, classic mansions of old England as they could with the skill and material at hand. In most cases the architecture was pretty seriously contorted, the work being done by carpenters instead of architects, columns being elongated and mouldings cruelly and wonderfully tortured. But it all served their purpose and it became "Colonial," the crude attempts of mere colonists to follow the wake of the cultured and wealthy of "merrie olde Englande." Today there is a class of antique worshipers, alleged trained architects, who fall down and offer homage to that "style" and in turn give us painful

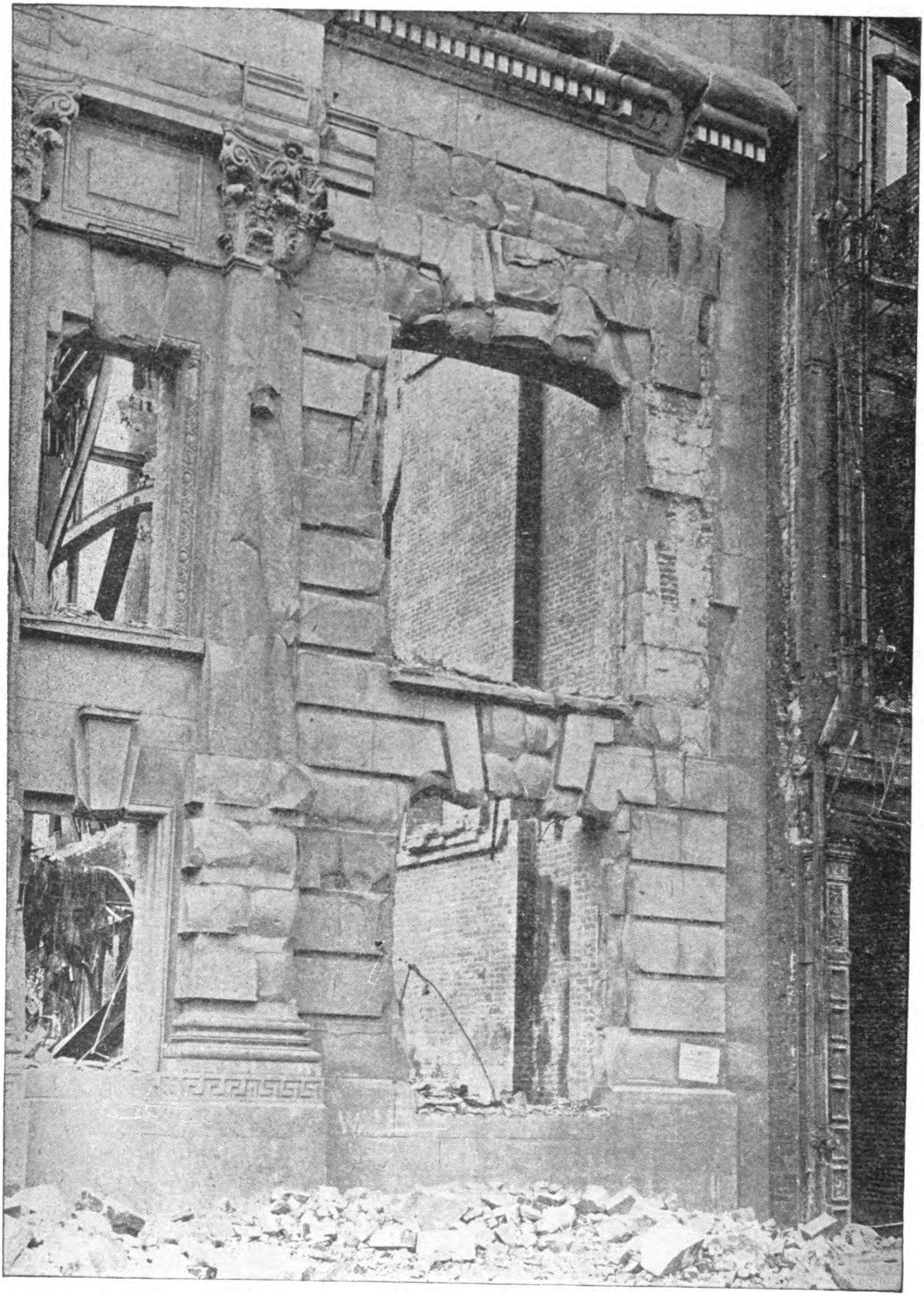


Fig. 23. The Effect of Fire Upon Sandstone, Usually no Salvage Whatever

imitations of that early work. With some nothing goes, particularly in domestic architecture, unless it be strictly "Colonial".

Stone and Brick. Some good architects and mechanics were imported ultimately and a few of our old buildings, still standing, are pretty good specimens of art. In the early eighteen hundreds they built their very important structures of great stone or granite walls, lead or slate roofs and partitions of brick or stone with floors of brick arches, groined or arched from wall to wall—pretty solid construction and mightily fire-resisting as to structure—though, of course, they did not protect their windows and simply filled those buildings with wooden trimmings, wainscoting and ceiling. Fire could and did clear all this out, perhaps even many times, but the structures remained intact. Of such is the old Treasury in Washington, one or two old buildings in New York and in some of the older cities. Of course, the rank and file of the buildings were, as they are still, either all of wood, or wood framing in outer walls of brick, stone, marble, etc. It is indeed pathetic to see some of those buildings and so many of our new ones with pretentious, ornate, and massive looking granite and marble exteriors, apparently as substantial as the rock of ages, but actually enclosing wooden joisted and framed construction—mere "whited-sepulchres".

Unprotected Iron and Steel. Then we began manufacturing iron beams, wrought-iron beams and girders, and cast-iron columns. These were used for the framing of the structures of buildings, the skeleton beams being spaced 3 and more feet apart and brick arches thrown from beam to beam, to form the floors. That was much easier and cheaper than groined arches from wall to wall. But we had not learned how to protect that iron work itself and even a very moderate fire in the contents of a room or its wooden finish and trimmings, warped and buckled the beams, for their bottom flanges were of course exposed; when this occurred, down dropped the brick arches and up went the fire into the next story, growing in intensity, almost melting the cast-iron columns, and softening them so that they bent and twisted, and ultimately collapsed with all that they supported above. Those buildings have been called fireproof and people wondered why they were not so; why, in spite of the theories of those times, when they were actually tested, they were found wanting.

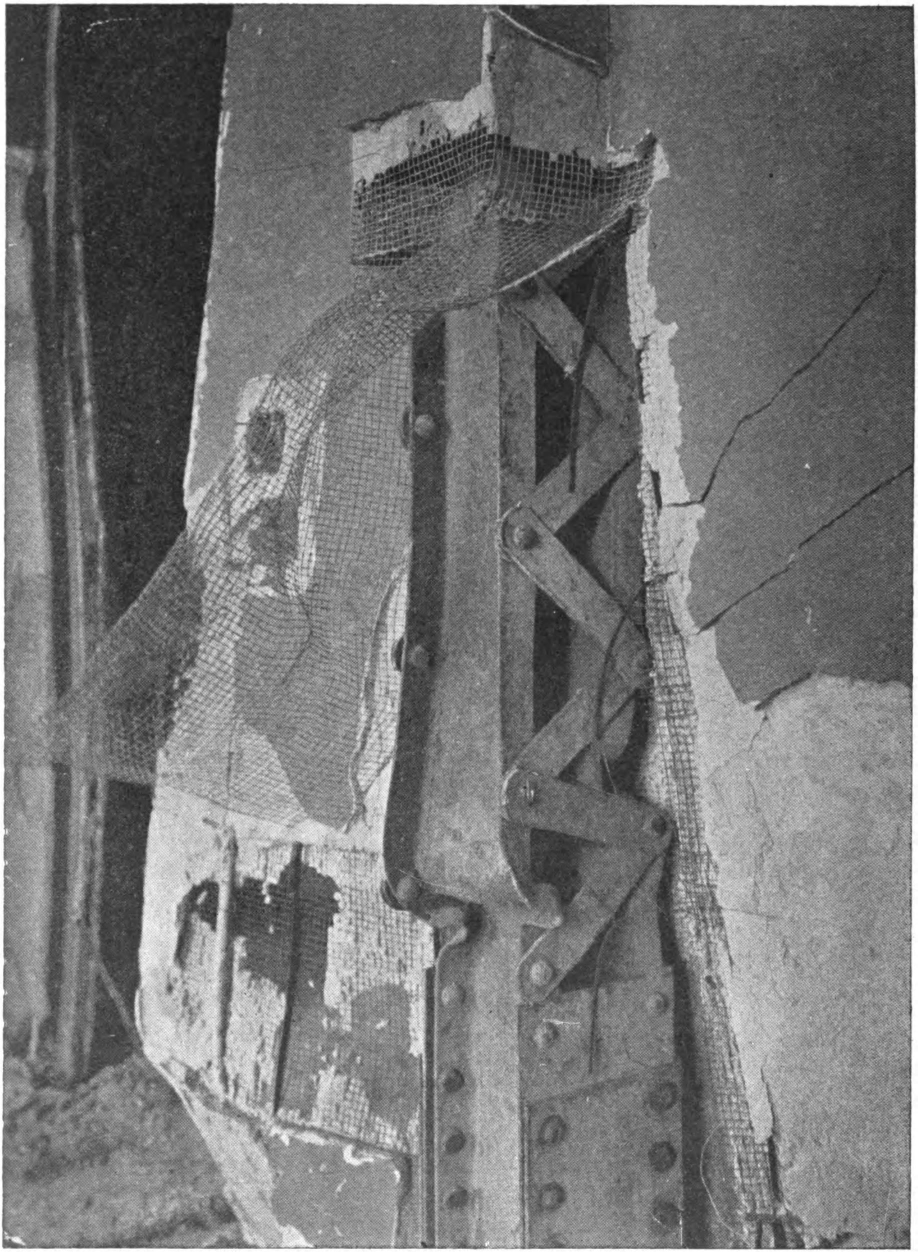


Fig. 24. What Happens to an Insufficiently Fireproofed Steel Column in a Fire

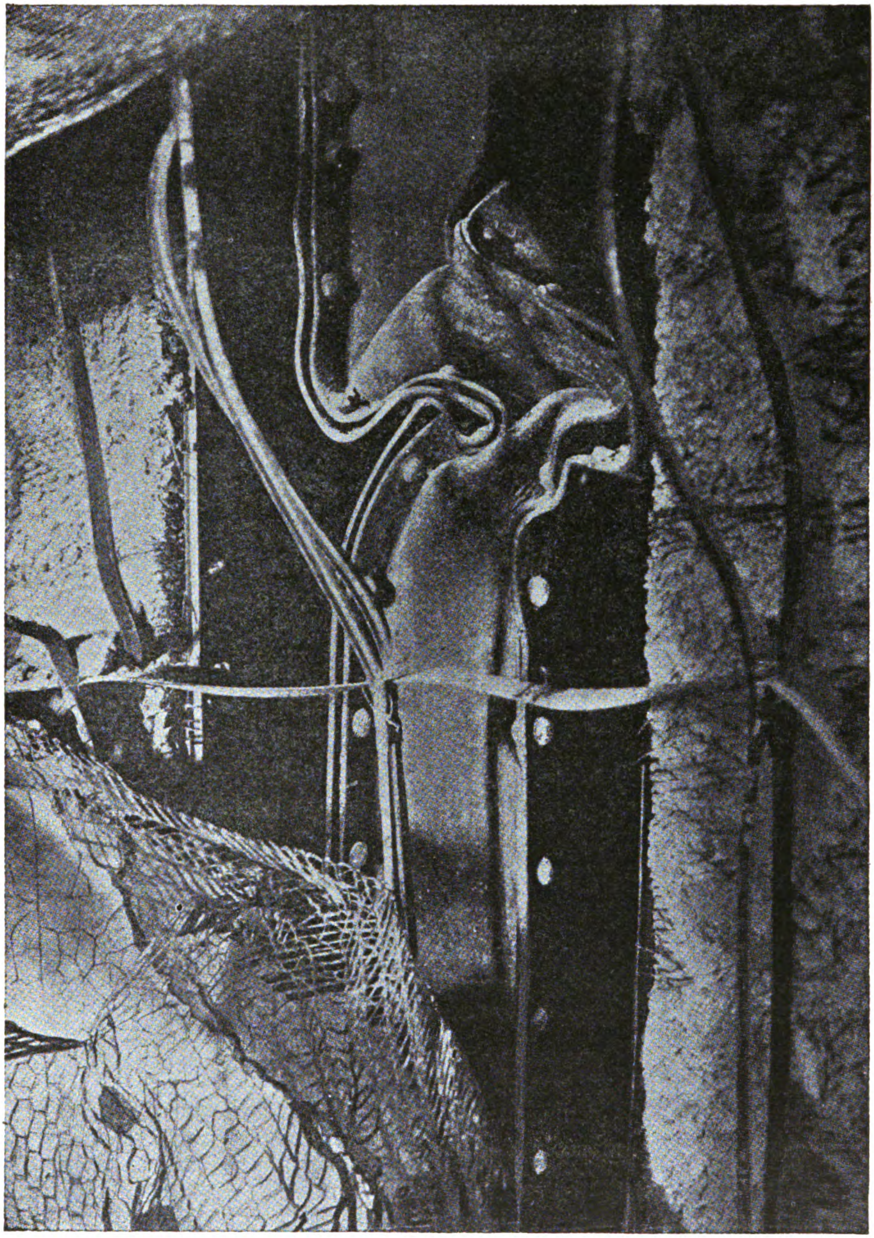


Fig. 25. An Unprotected Column Will Twist up Like—Cork-Screw
Imagine what happens to the construction it supports

Tile Protection. Something over thirty years ago they began making brick into odd shapes, hollow clay tiles, burned the same as brick, and used them to surround and protect the iron (or later the steel) columns, girders, and beams. The blocks were shaped into radial jointed sections of considerable depth that formed arches between the beams, special sections being made for roof building, partition tiles, furring, and what not. That really was the beginning of a new era in building when it was made possible to thus thoroughly protect all the metal parts of a building and actually construct its ordinarily most vulnerable portions, of an imperishable, fire-resisting material. It permitted the greatest elasticity of arrangement. With the old groined or domed arches of not too great rise, rooms were restricted to thirty feet, or far oftener less, between supports; with this new method, steel girders and trusses could be used, thus extending the points of support indefinitely, and all this framing was protected by a material that in its manufacture had passed through heat so infinitely more intense than could ever strike it again in a conflagration that it was practically immune to all fire attack.

Imperfect manufacture, a desire to make the webs and sections too thin (a commercial profit), sometimes resulted in this tile being damaged in a bad fire; the ceiling flanges have dropped off—owing directly to unequal contraction of the parts of the tile *after* the fire—and even some of the tile have been in themselves irreparably damaged. However, the units being small, new tile could be substituted with as great ease as a new pane of glass could be put into a window and the damage was never "major," *i. e.*, never such as to jeopardize the safety of the entire building, nor even the story above the fire.

The only cardinal damage that can happen in a tile fireproof building is when the tile protection is not thoroughly secured to the columns or to the bottom of the beams, and of course, when once the steel itself is exposed, that steel portion is subject to all the ills we have seen it was heir to and actually suffered in the old unprotected steel frame and the "semi" fireproof buildings. Only gross ignorance or culpable negligence, however, can account for such defective work being done; this tile work is clearly in view all during the process of construction and the superintendent is indeed lax who will permit it being poorly done or not discover it if it has been poorly done in his absence.

Fig. 26. The Effect of Fire Upon Too Thin and Dense Hollow Tile

Tile fireproofing has been splendidly improved in the thirty years of its use. Endless minor tests have been made in addition to the test of passing through great conflagrations. We have seen wherein it could be bettered and this improvement has been made, the work has been systematized and made standard; today it stands the most nearly perfect fireproofing so far devised.

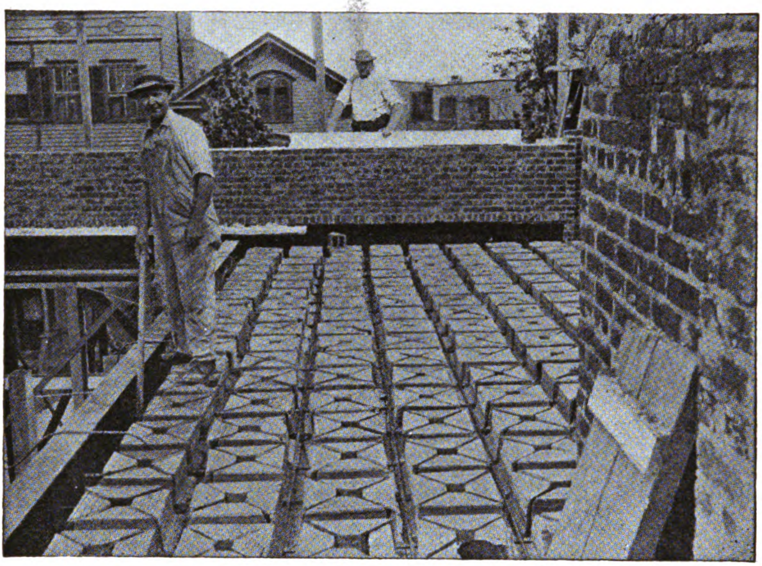


Fig. 27. A New Form of Concrete or Clay Blocks—Four Sections Forming a Block
The intervals being filled with concrete forming beams in either direction; an excellent floor construction

Many years ago when tile was still expensive work, in fact, prohibitive save in the most costly buildings, some queer things were done with it. I well remember the old West Hotel in Minneapolis, for instance, a costly and prominent structure, but yet one in which all steel and tile was too costly a system to use. We used the regular wood joists resting on brick walls, tile partitions, and steel beams; a light tile ceiling was used at every story and the plastering was applied directly to that tile instead of the usual wood lath. Many a fire was started in that hotel, but, owing to even that feeble protection and prompt action on the part of the firemen, all were speedily extinguished. A year or two ago they had a disastrous fire there, the furniture was destroyed and much of the finish, the smoke was dense and several lives were lost. Yet that same old tile protected the wooden floor construction so well that there was scarcely any actual damage done to the structural parts of the building. It was redecorated and refurnished in quick order and ready for use at comparatively little expense for structural repairs. Of course had it been a conflagration, like the Baltimore or San Francisco fire, instead of a local, internal and somewhat confined fire, there would have been but a few charred and ruined walls left to tell the tale. To be really effective the whole thing must be done thoroughly, as near perfection as can be.

Corrugated and Plate Floor Construction. What might be called a direct successor to the brick-arch between-beams construction was the scheme of *bending corrugated metal* in arch form between similar beams and filling up on top to the finished surface of the floor with a lean concrete little better than broken stone and rubbish. In a hot fire this sheet metal would, of course, distort and warp out of position; the flanges of the beams, being unprotected, would also curve and curl, and the concrete, being generally so very poor, would offer no resistance at all. The usual result would be that the whole thing would "go by the board."

Another device which was tried and used quite extensively was *buckle plate* flooring. Heavy cast-iron plates dished upward, each in the form of a very flat arch or groin rested upon iron beams set two or three feet apart. Some of these plates had raised webs upon their upper surface to still further strengthen the metal; and later they made them of forged, pressed, and shaped wrought iron. In some cases these plates served as a floor and ceiling both, but generally only as ceiling and support and were topped off with a filling of several inches of concrete and a finished floor of cement.

These corrugated and plate floor constructions were used almost exclusively for warehouse and factory construction, the heavier buildings (more "semi-fireproof"). Seldom was any attempt made to protect the columns and girders, with the result that a very slight fire in the goods or contents would find nothing to feed upon, in all this iron of the structure, and would be readily extinguished. One principle of fireproof construction had been put into practice and after each little fire every one clapped his wings, so to speak, and proclaimed that this indeed was fireproof construction. But if the fire was not quickly discovered and got pretty hot, hot enough to affect any or all of the exposed iron work, columns collapsed, floors went down, the building was wrecked—though not *burned* down—and people were as prompt to condemn and to say that of course that was not fireproof construction and there was not and could not be any such thing as real fireproof construction!

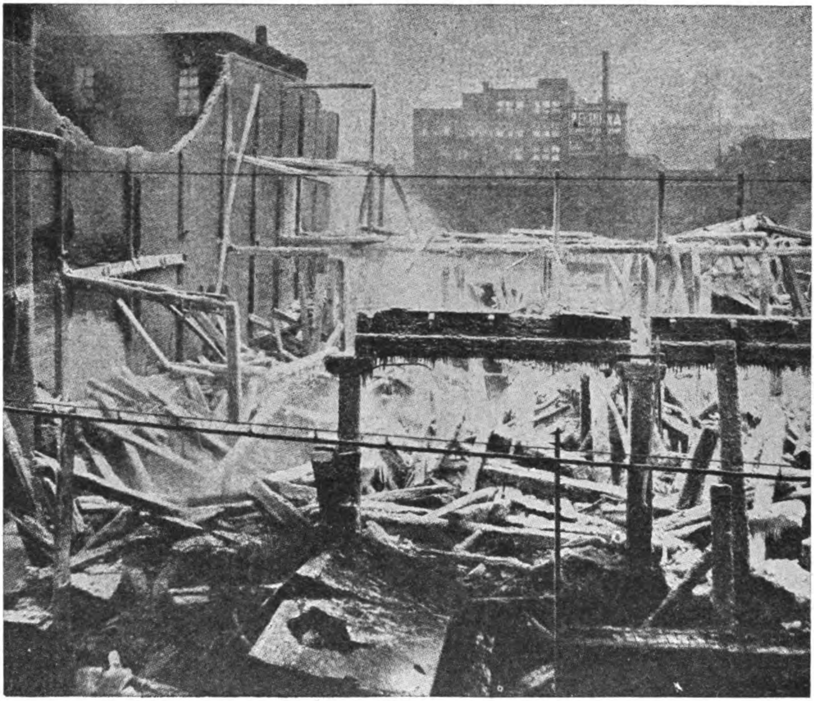


Fig. 28. Another "Slow-Burning" Fire; 33 Minutes Destroyed the Usefulness of This Building

Mill Construction. Mill and warehouse fires were disastrously common and, naturally, engineers and builders were spurred on to try and devise a construction that would lessen the losses. "Mill construction" or, as it was also called, "slow-burning construction," was evolved. It served its purpose as a step in the general progress but, largely through the insistent efforts of one enthusiast, the late Edward Atkinson, engineer, insurance man, statistician, and publicist, it has been kept in prominence long after its real usefulness was over, and is today used to a certain extent in warehouse and factory construction.

The "slow-burning" theory is a simple one to illustrate. Touch

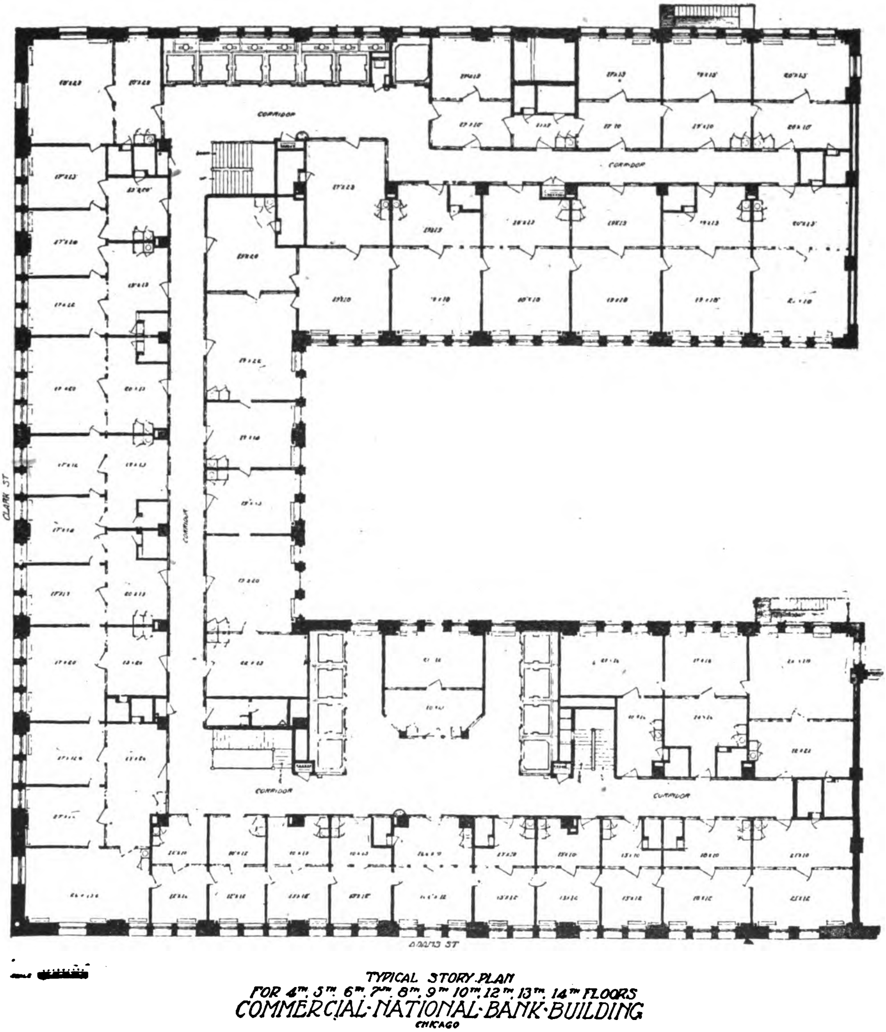


Fig. 29. A Typical Fireproof Office Building, The Commercial National Bank of Chicago
There would have been better light and greater safety from fire in the light court had it been reversed and opened upon a street front instead of upon adjacent buildings, and the stairways ought to have been enclosed, thus separating the stories

a match to a lot of small pieces of kindling wood in a grate and you will have a roaring fire in short order—total destruction of the wood; if you throw water on the fire and extinguish it there will be but a few crumbling cinders and ashes as a residue. But if you have a huge log in the fireplace it takes time and much kindling to get it ablaze, and once started it burns slowly. Throw water on the fire, extinguish it, and you will find that the log is only charred upon the surface; the heart is intact. If you test that log as a support on end—a column, for instance—its carrying capacity is, of course, only depreciated to the extent of the charring. If the log or post was 10 inches square and was charred an inch, it would naturally still be equivalent in strength to a post 9 inches square.

So with slow-burning or "mill" construction. Instead of using joists and studding—the ordinary "kindling" in a building—only timber of large dimensions is used, and that without any enclosed air spaces—fire conductors—between floor or walls, air ducts that the usual joists and studding construction always forms. The posts and beams are of large sizes and always larger than the actual weight-bearing construction requires, making allowance for the weakening due to charring from a possible fire; the floors are of heavy timber 4 inches and thicker, laid tongued and grooved, and generally laid diagonally and covered with another thick surface of finished flooring. All of this solid timbering, the floor construction, rests *upon* the outer walls and is not bolted or otherwise fastened into those walls, so that if any portion of the timber work does burn out or is thrown down it will not pull down the walls too.

If built in strict accord with the Atkinson rules, there are no openings in floors; the brick and iron stairs are enclosed, as are also all elevator shafts, in outer brick bays; floors are drained and scuppered to the outside walls; and then every ceiling is well studded with automatic sprinklers. With such construction, particularly if the timbering be of hard wood, the resistance of a building to an ordinary fire is very great. The system has saved millions of property, particularly in the mill districts of Massachusetts and the South, but it has its limitations well defined. Let the sprinkler system get out of order, or the watchman fall asleep and the fire get a big start; or let the building be surrounded by a lot of "ordinary" buildings and, like the log in the grate, it will not only ultimately be totally destroyed but it will make a roaring, intense fire the while. The system *is* fire-retarding, slow-burning to a degree, in a slow fire, a step in the right direction, but not in any sense *fireproof*.

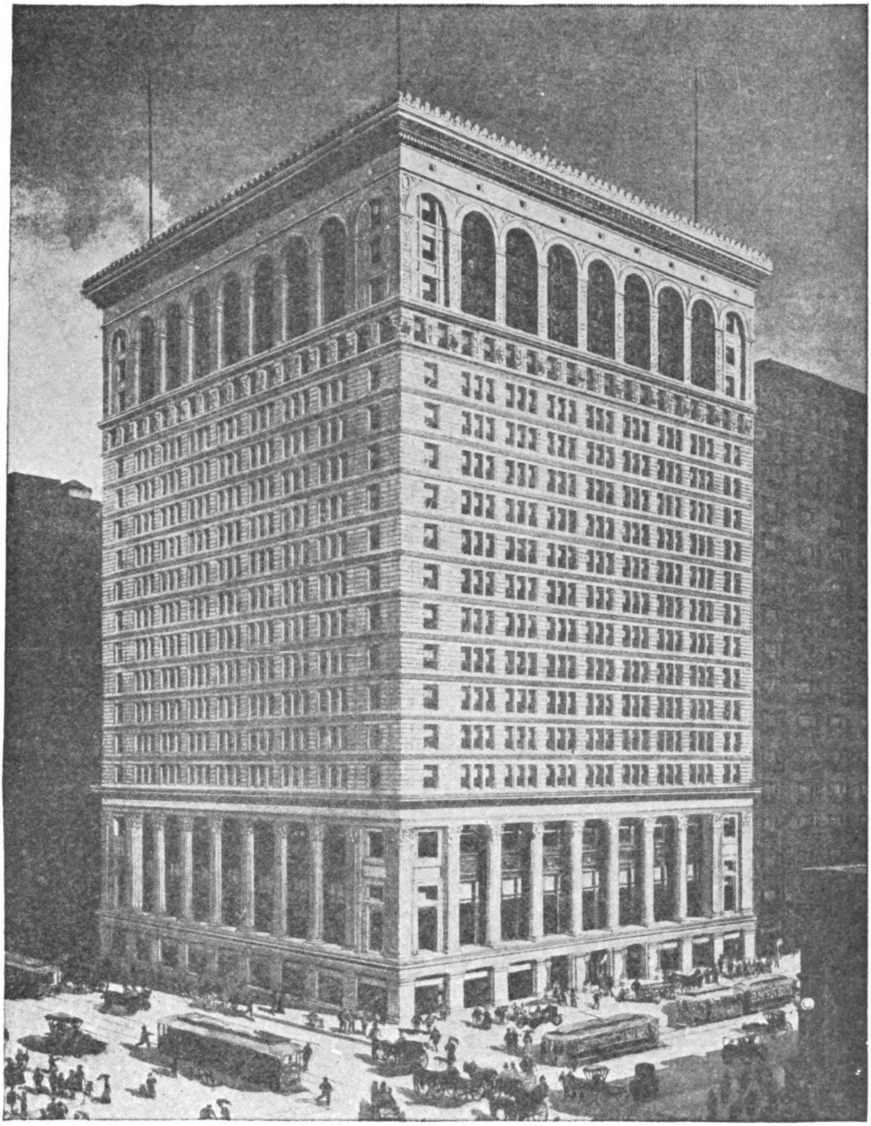


Fig. 30. Exterior of the Commercial National Bank at Chicago

Fig. 31. The First National Bank, One of Chicago's Tall Office Buildings, as Well Fireproofed as any Specimen of its Kind

Other Retardants. Wire lath and a host of variants in the way of expanded metal and woven wire mesh have been and still are used to lessen the fire danger. Ceilings of wire, or such expanded metal, are hung suspended well below the wood joists; such woven wire lath is stretched upon the stud partition, it is wound about wooden posts, and in all these positions when plastered, it is just that much extra protection of incombustible though damageable covering to the combustible or damageable structural parts of a building—retardants of fire but not *fireproof.*

Along those same lines are the endless patent partition and ceiling systems, "plaster board," magnesia-felt, great thin blocks of exceedingly light and incombustible plaster on burlap, plaster-of-Paris blocks, and slab partitions of every shape and material imaginable. These are good in their way, unburnable, but damageable by fire and destroyed in a conflagration.

Steel-Frame Buildings. Very soon after the first fireproofing tile was used the steel-framed skeleton construction of buildings also came into vogue. They are really complements, essential to each other, the first the natural and logical integument of the second. Steel without tile or such protection would be valueless for building, insofar as fire is concerned; certainly we never could have gone up to fifteen, twenty, thirty and more stories with the unprotected steel. True, new forms of tile have been devised whereby a house or other building may be erected of it only, save for a very little reinforcement of metal bars and without any steel framework; but the generally accepted construction, particularly of the tall commercial buildings, the "fireproof" structures, has been of steel frame and tile protection, floors and partitions; or combinations of tile and concrete protection, and sometimes all concrete protection.

The steel frame was an American invention. Many engineer, claim the honor and some are supported by patents that, howevers have never "stuck". Some do me the honor, but I really believe that it was no one man's idea. The necessity for going higher in the air was before us, for property was beginning to be immensely valuable in our cities thirty years ago; the demand existed, the solution of the problem was simple and, undoubtedly, many thought of it at the same time. The fact remains that the late W. L. B. Jenney, one of Chicago's foremost architects, was the first one to actually so construct a building.

Like most big inventions the thing was simple enough, and surprising it is that it was not done long before. To carry a build-

Fig. 32. Chicago's Home Insurance Building, the First Steel-Framed "Skyscraper" Ever Built

ing to any considerable height the old way, where masonry walls carried all the loads, the outside walls of a fifteen- or twenty-story

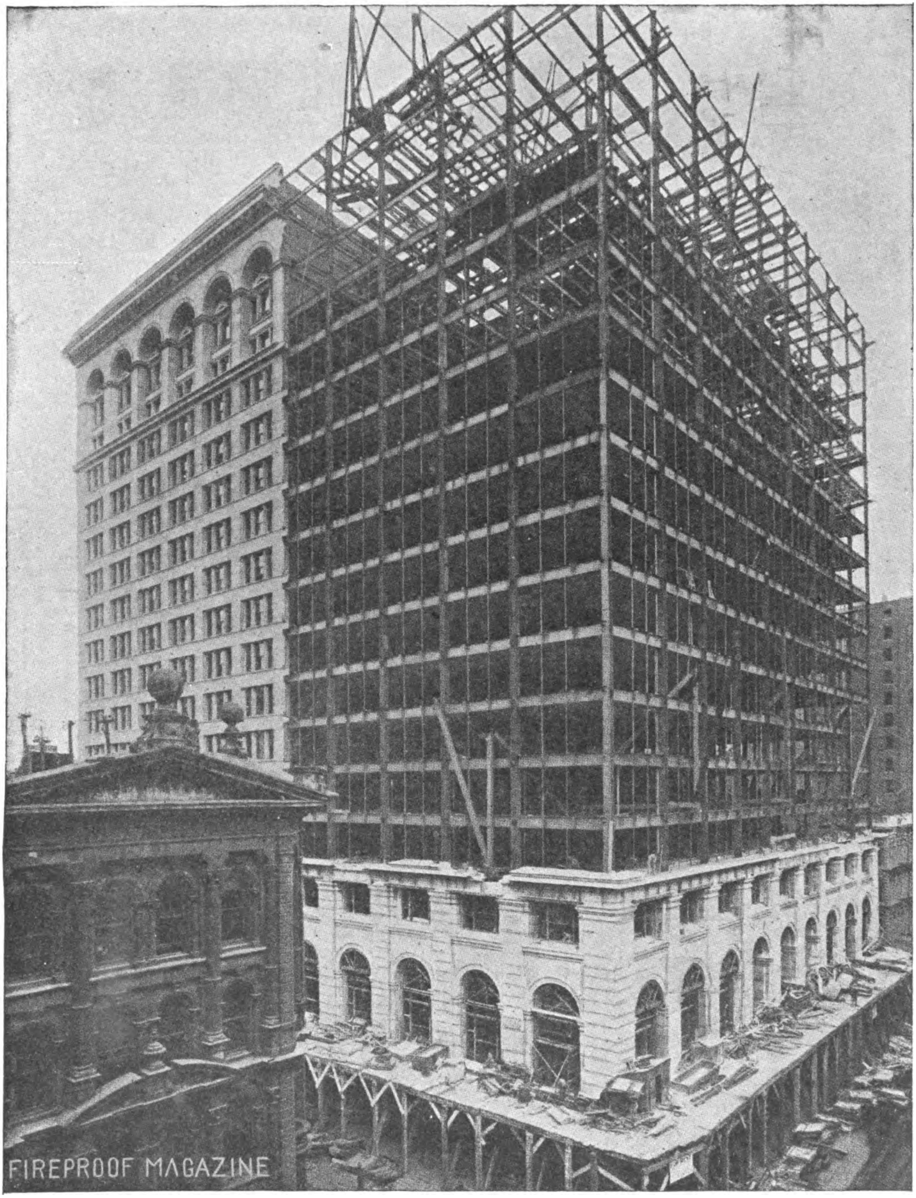


Fig. 33. Putting up One of the Great Steel Framed Monsters of Chicago, the First National Bank

building would have to be prohibitively thick at the lower stories. On a narrow lot, the first or most valuable story would virtually be all wall, and property was too valuable to be so used. The most natural thing to do was just what we did, carry up a framework of iron or steel columns and girders and beams—a steel column 12 inches square will carry as much concentrated load as a masonry wall 4 feet thick and 20 feet long will carry a distributed load; the difference between from 60,000 to 80,000 lbs. per square inch ultimate resistance to crushing in steel or iron and only 6,000 to 13,000 lbs. in masonry, plus the thickness required in the latter for the necessary vertical rigidity and pyramidal spread—and, outside of all this framing, and supported at each story by shelves and such fittings attached to the outer girders, or by the girders themselves, build the outer masonry or curtain walls of such *thickness* only as is needed for walls supporting nothing but themselves and but one story in height. This also permits what is most startling to the layman, the building of such outer walls at any point upon the completed or partially completed frame, regardless of the fact that the walls below are still unbuilt. This is not done as a *tour de force* or whim, but oftentimes because the stone or other material happens to come that way, and, therefore, instead of delaying all work until the material can be had in regular sequence of first story first, and so on up, it is built in as it comes to hand.

Reinforced Concrete. As far back as 1869 French engineers had patented some forms of reinforced concrete construction. The first American patent was issued in 1876 to an English-American, T. Hyatt, for a "combined cement and iron construction of floors," but like everything new or revolutionary it was long "a-borning". A very few buildings were so erected in those early times and it was but ten years ago that it became at all popular, and but five since it is really common, although even now there are cities of some size, where there is not yet a full-fledged reinforced concrete building.

Concrete a Potent Material. No one material ever devised or discovered has anywhere near the potentialities of concrete, plain and reinforced. The amount of experimenting upon it, chiefly in the past ten years, has been phenomenal and yet it is still in its adolescence, essentially its experimental stage. We have barely begun to know what can be done with concrete and with its binding ingredient,

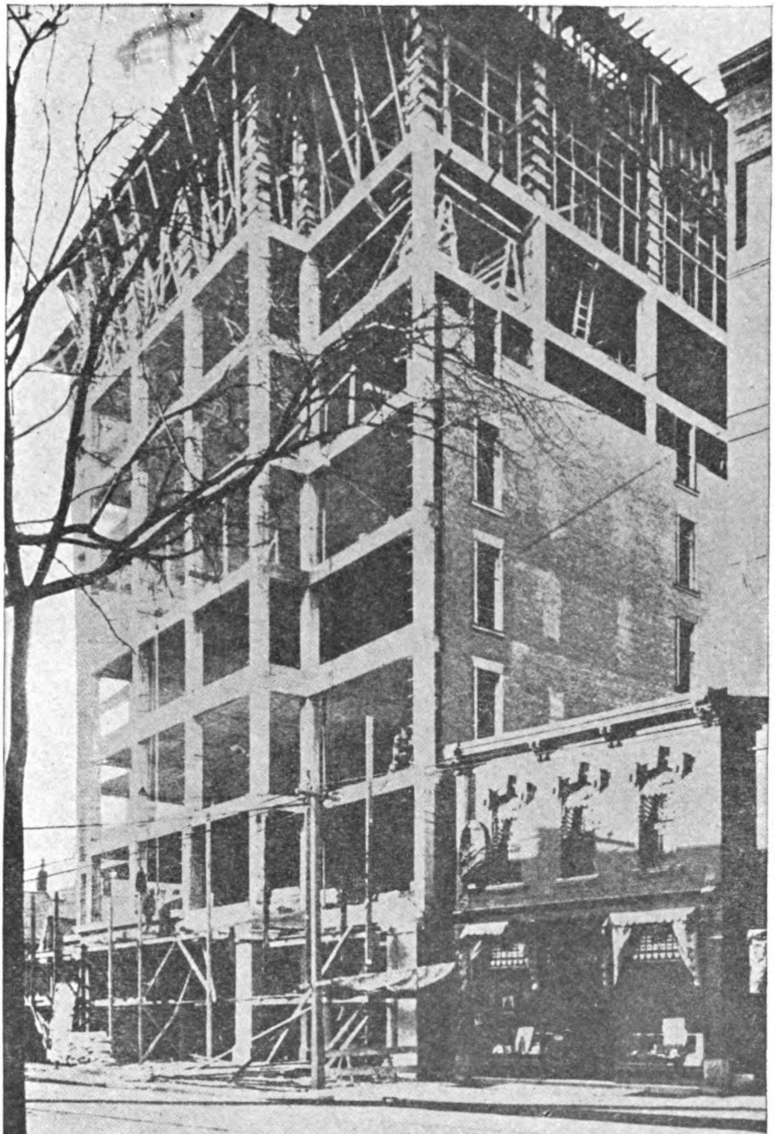


Fig. 34. Carrying up a Reinforced Concrete Building
Columns, beams, and floors of concrete and outer walls usually of brick

cement, and still we are using much of it. Of Portland cement alone, laying aside the many other kinds in use, this country produced and used last year over 60,000,000 barrels; in 1890 the total production scarce reached 300,000 barrels.

Very high authorities are still at outs as to details of construction; each one has experimented and believes his theories right and all others wrong. But efforts are now being made to reduce

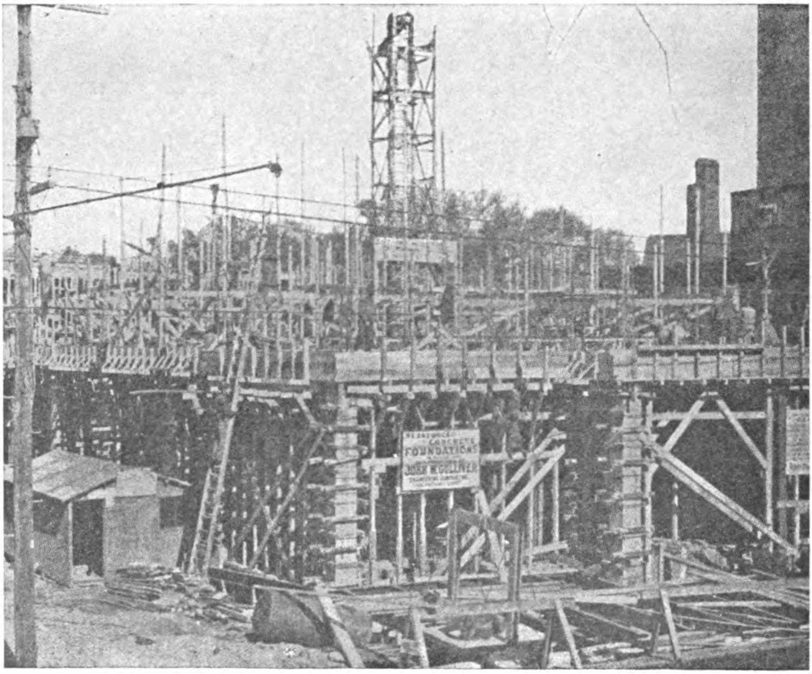


Fig. 35. Wooden Frames Have to be Built for Every Member
Greater safety and economy will abtain when movable metal forms are more generally used

it all to a positive science, to standardize it, and to establish real constants.

Uses of Cement. Cement, chiefly as a basis or binder in concrete, is useful in a thousand ways and there are possibilities of its use in still other thousands. It is supplanting wood and many other materials. As wood becomes more and more scarce and consequently dearer, cement is produced cheaper, and in larger quantities, and there is absolutely no possibility, as long as the earth exists, of

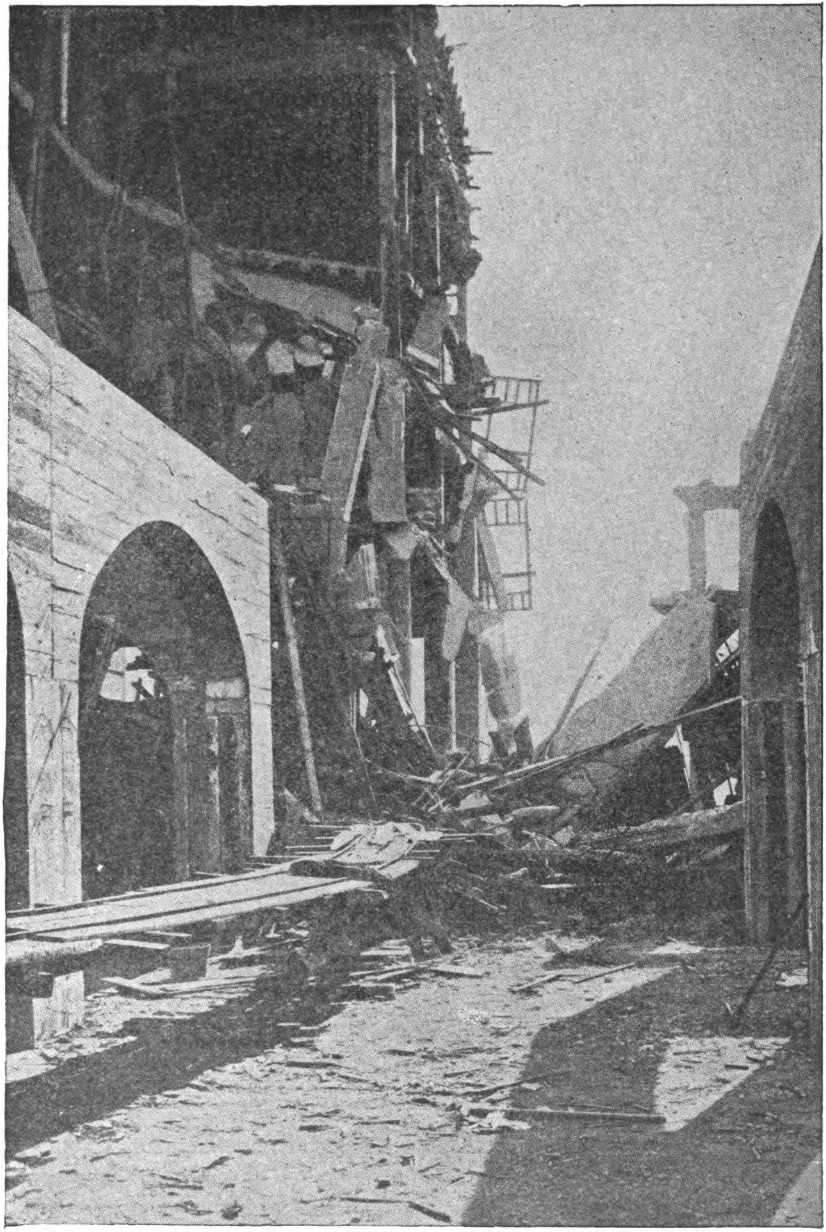


Fig. 36. The Bixby Hotel (California) Collapse, a Reinforced Concrete Structure

exhausting our supply of materials of which cement is manufactured and concrete formed. It is used upon the farm in making floors, stables, bins, troughs, fence posts. It is the most plastic of materials, easily moulded and always available. It is the basis of our roadways and is made into sidewalks, gutters, curbs, lamp posts, steps. It is fashioned into buildings, bridges, culverts, railway sheds, steamer docks, and even boats and barges themselves; it can be made into mouldings, carvings, ornaments, and is also used in tree doctoring and what not. It has the great advantage of being a "local" material anywhere. With most materials, stone, iron, brick, etc., the quarry or manufactory or shop is established at some convenient point and the finished material is shipped to wherever it is needed, often long distances, thus making the transportation costly. Not so with concrete, for in this case only the cement, a small part of its total bulk, need be transported from the place of manufacture, while the sand, broken stone, slag, or the other inerts of concrete, and water are always procurable at trifling cost nearer by. The making is done upon the site.

Concrete Design Nct Yet Standardized. In construction, where used in compression only and with large factors of safety, in great masses, piers for foundations, solid walls, bridge abutments, docks, solid arches in bridges and culverts, it is the ideal thing, easier to handle than stone or granite and as strong if not stronger. It is only when combined with reinforcing-metal, that there is danger in its use, in the construction of reinforced concrete buildings and bridges and such structures.

Many elements enter into this danger. There is no general and accepted standard of constants, no accepted system in figuring its values. Few men are really qualified to design such construction and only the most careful and able mechanics should carry it out. It is sometimes advertised and exploited as a *cheap* construction and often efforts seem to be directed toward still further cheapening it by poor labor, skimped materials, and insufficient superintendence. Result: In the past few years there have been a number of collapses of concrete buildings, fatal ones, and the mode of construction that should be made so effective, so popular, has been discredited.

Skilled Labor and Great Care Necessary. My objection to the use of concrete by every Tom, Dick, and Harry may perhaps be best

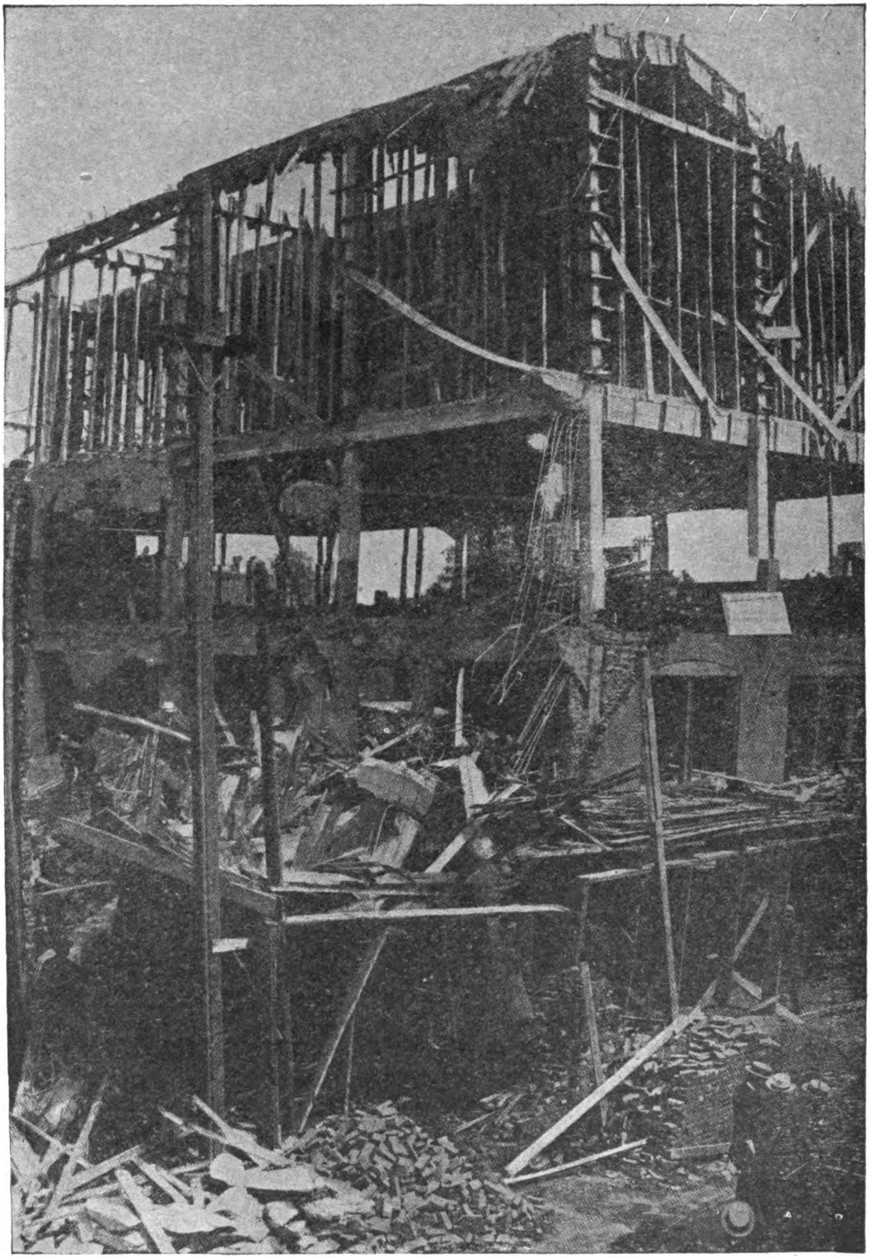


Fig. 37. The Collapse of a Reinforced Concrete Warehouse (Philadelphia) while Under Construction

expressed by an article recently published by a concrete engineer in one of the architectural journals that devotes so much space to the new cult that it might almost be called an "organ". The following excerpts will show what is meant:

The ease with which reinforced concrete may be applied to almost any form of construction, and at the same time the necessity for properly reinforcing so as to counteract the effect of tensile strains and stresses, really divides the work into two heads—the architectural and the engineering. Therefore, in works of importance it is desirable that the drawings be carefully gone over by an engineer of practical experience in this method of construction in order to secure a successful outcome. The work must be subjected to a rigid inspection at all times, and the contractor is held responsible for the obtaining of certain test results. *The most active inspection will not always prevent poor workmanship or faulty construction, either of which can destroy the strength of structures made by the best materials.* The proportion of the concrete may not be in all parts according to specifications; good judgment may not have been exercised in gauging the quantity of water. If too much water is added, the strength of the concrete, and especially its coefficient of elasticity, will be decreased; if too little water be added the adhesion of the concrete to the reinforcing metal will not be sufficient.

Great care must be exercised in the inspection of materials that they be made up to the standard required. *All* cement should be tested on the ground to ascertain its tensile and compressive strength, and to establish the evenness in grade, and *no cement should be used which shows disintegration in the boiling test.* The sand must be carefully inspected to see that it is clean and free from impurities and not too fine—not over 25 per cent of its bulk should pass a 30 mesh sieve. The crushed rock must be hard and free from shale or decomposed particles, and not too coarse—all should pass a ¾-inch sieve. The steel, if not twisted, shall be tested to ascertain if its quality is correct. If twisted, the twist should be measured to ascertain if it has the correct number of turns per foot, according to its size. Hard steel or what is termed "high carbon steel" should not be used in tensional work as it is liable to snap when loaded. Quite as important as the quality of the material is the placing of the same.

In order to secure the intended action of the steel, care must be exercised that it be placed on the lines of the stresses created in tension, shear or compression; otherwise its effectiveness will be lost in whatever degree it is misplaced. The misplacement of the reinforcing metal changes the construction from reinforced concrete to simply a protection of steel by concrete and, unless the steel be excessively heavy, *failure is sure to result.* Care must also be taken with the concrete that the proper percentages of its component parts are properly massed and mixed, and that the proper amount of clean water is incorporated. Great care must also be exercised in the placing and tamping of the concrete in the forms in order to secure uniform density throughout the entire mass and perfect contact over the entire surface of the reinforcing metal. . . .

Limitations of Concrete. Concrete, particularly reinforced con-

Fig. 38. Showing the Effect of Fire Upon Some Reinforced Concrete Construction. The reinforcement too near the surface, became heated, expanded and allowed the whole to deflect. Some of these beams and slabs are deflected as much as 12 and even 18 inches

crete, is problematic, and every day a fresh surprise is given us in the unexpected way in which it acts under certain conditions. A good illustration of this is the failure of concrete slabs in the roof of the train shed of the La Salle Station, Chicago, after eight years of exposure to moisture and gases. An extract from the Engineering News of July 21, 1910, gives the details:

The failure (by disintegration) of reinforced concrete slabs forming the roof of the train shed of the La Salle Station, Chicago, indicates the necessity of preventing the access of moisture and gases to reinforced cinder-concrete, or the advisability of using other material in cases where there is liability of exposure to such influences. The gradual disintegration of these roof slabs has necessitated their renewal over a considerable area of the train shed. It appears upon further investigation that the porous character of the concrete and the use of cinder aggregation were the causes of the failure. The original slabs were about 5 feet long, 2 feet wide and 3 inches thick, reinforced with expanded metal of about 3-inch mesh and No. 12 gauge. The exterior shell was about ½ inch to ¾ inch thick and was composed of gravel concrete; the interior portion was of cinder-concrete, probably for the purpose of reducing the weight of the slab. According to official information, the cause of the disintegration was that the gases and moisture from below penetrated through the gravel concrete shell and entered the cinders. This led to the rusting of the steel, causing it to swell (or enlarge in section) in places and crack off the concrete. The new slabs are made of stone concrete throughout, and when finished they are treated with a solution which is designed to close and seal all pores, so that neither gas nor moisture can penetrate the facing of the concrete. Whether any thought was given to the possibility of corrosion of the steel reinforcement when the roof covering was designed (some eight years ago) we do not know, but if so, it may have been assumed that the ventilation of this lofty arched roof would be sufficient to dilute and carry off any deleterious gases.

Concrete is also staunchly advocated as a "fireproof" material. I contend that it is one of the most fire-resisting but not "fireproof," not nearly so much so as is brick or any of the other burned-clay products, although it comes next in order to these.

Cities are now legislating specially upon that subject, comprehensive regulations are being passed providing for special inspection and tests; in some places it is made obligatory that the work be carried on only by experts, and it is being put upon a sane and safe basis.

Steel and Tile vs. Reinforced Concrete. In the course of years the question of fireproofing a building has been reduced to this—regardless of the hundred and one other items that are necessary to make it thoroughly fire-resisting—*which system of structural fireproof-*

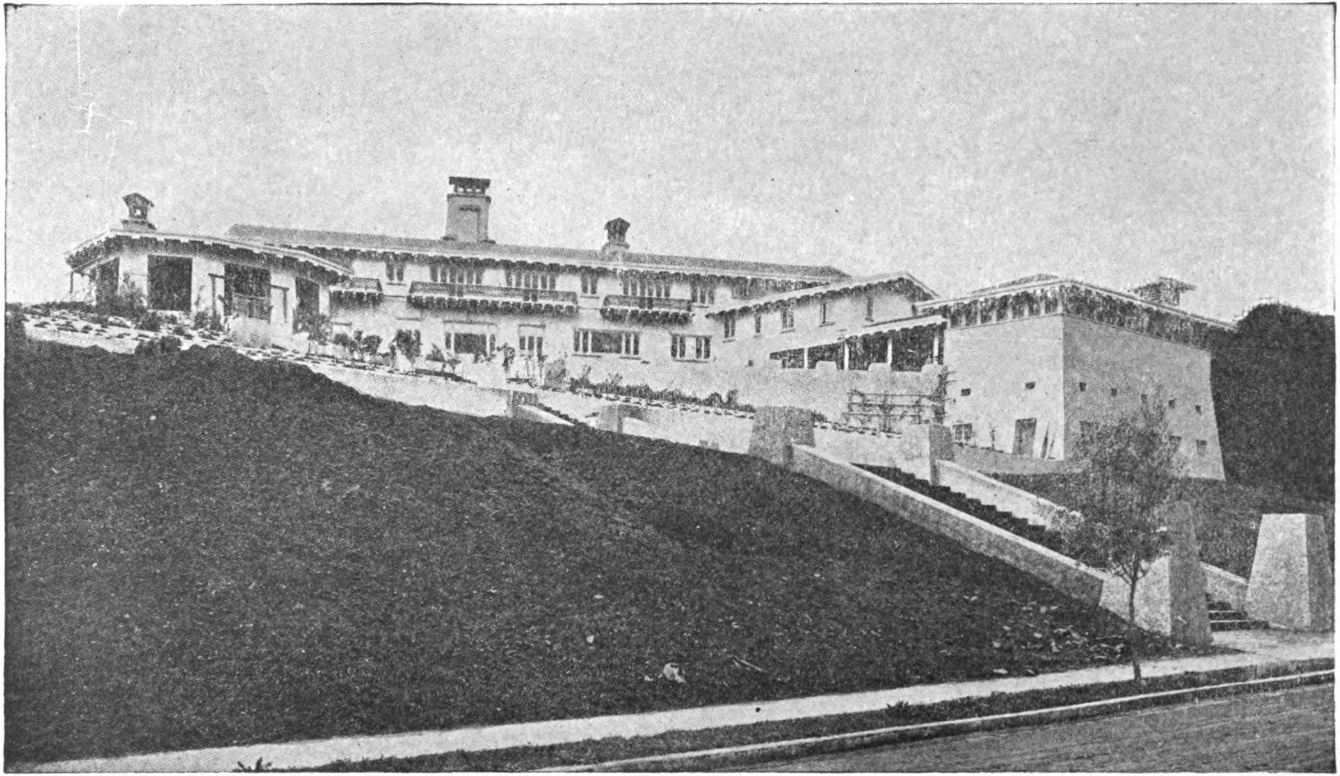


Fig. 39. A California Reinforced Concrete House

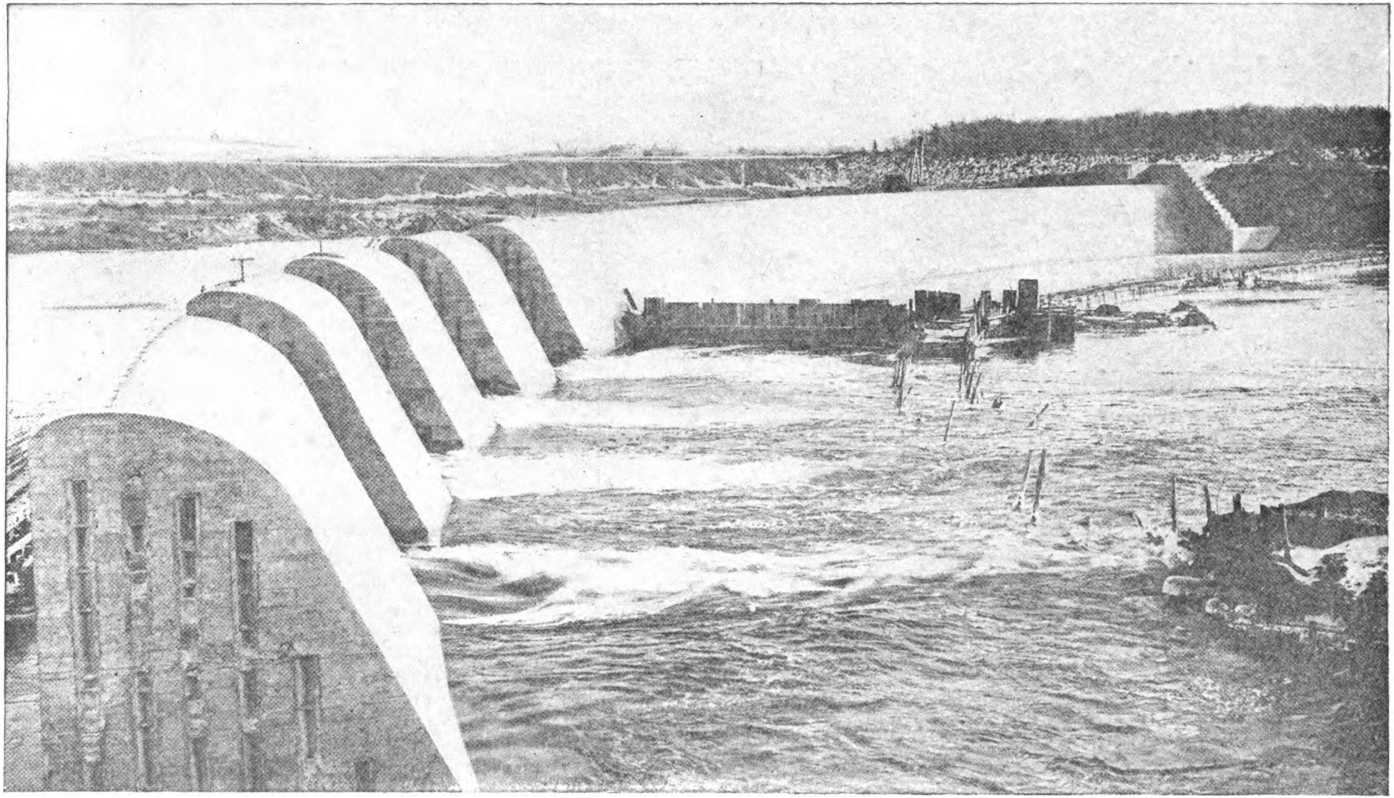


Fig. 40. For Dams, Piers, Bridges and Such Heavy Work Concrete is Away Ahead of any Other Known Material

It must be also added that in this heavy engineering work it is always under the superintendence of most skillful and careful engineers and is designed by masters in the science; on the the other hand concrete buildings are generally erected by haphazard design and most often entrusted to very ordinary builders, simply because they will do it for less money than the other man. It is small wonder that there has been so much trouble with it.

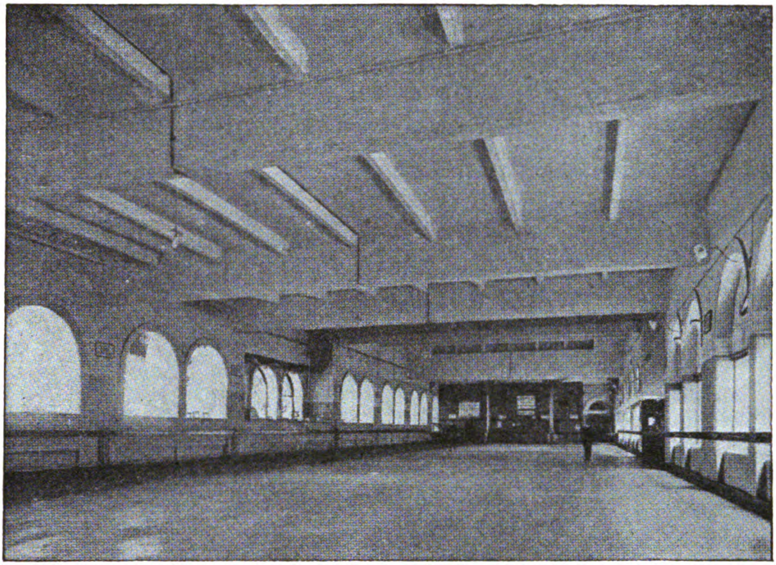
ing shall be used; (a) a steel frame and hollow fireproof tile protection, floors and partitions, (b) a steel frame and concrete protection and floor arches, or (c) a reinforced-concrete construction? And the question is asked insistently and debated acrimoniously. It is really *clay tile* vs. *concrete* fireproofing. And it is not a merely academic question, nor one that interests only specialists and the different manufacturers, but is one of fact, a large and most important fact.

The best engineers now concede that reinforced concrete is a structural material and requires protection as does steel and iron, that in itself it is fire-resisting but its disintegration under fire is liable to be such as to expose the reinforcing steel or so to weaken it as to render the whole construction dangerous. Some advise that, like the steel, it be covered with protecting tile, while others—and they are perfectly right—maintain that all that need be done is to make the floors and beams and girders thicker and the columns larger all around by an inch or two more of concrete than is actually required for the strength of the member, such additional material serving only as a fire retardant and the structural value of the member itself being in no way impaired even if its protecting coating be entirely destroyed. This is on the same principle as the making of the wooden members of "slow-burning" construction larger than needed, so that an inch or so may burn off without in any way affecting the stability of the building. The cheapest concrete could be used for its protecting coat, viz, cinder concrete, which is really one of the most fire-resisting of concretes—provided you are sure of cinders and not coal dust and dirt—but the authorities are afraid of using it in structural work on account of its destructive effect upon the steel reinforcement, so that in most cities it is absolutely barred in reinforced-concrete construction.

Burnt clay is unquestionably the most fireproof, the least damaged by excessive heat, of anything that has ever been or is known and used in the building trades! And it is not of yesterday or the day before. Like gold that has been the standard of value from time immemorial, so is burnt clay the most resisting element, the standard material of imperishable construction. Examine the ruins of ancient Greece and of Rome and you will find monuments of stone and of marble crushed and battered and decayed and their dates a matter of question and speculation; but whatever you find of burnt clay is intact, clean cut, exactly as it was fashioned by the hand of the primitive clay worker. In Egypt, in Assyria, in Babylon even we have sun-baked bricks 3,000 and 4,000 years old and as good as new. At first Christian works were fashioned in the clay products and the art was carried to great perfection in the first capital of Christendom, Byzantium. And since that time—cavil and carp at that notion as we may, we must concede that Persian art and then Arabian art (preserved to us by a strange anomaly by the so-called barbarian and all-destroying Moslem) has been the refining influence of our modern art. And the perfection of its expression is to be found in its sub-art of ceramics—the burnt-clay products.

Whatever deterioration or ruin there may ever have been in the brick and tile buildings of antiquity or of modern times, has never been caused by the disintegration or any inherent fault of the material itself, but has always occurred through the failure of the binding material, the mortar used in cementing those parts together. The concrete enthusiasts point with pride to the noble Pantheon at Rome as the very apogee of concrete construction, the greatest piece of vaulting ever done in the olden times. It may be well to add, lest we forget, that the main ribs of the magnificent vault are built, not of concrete, not of stone, not of steel, but of a far more perfect material than any of these, brick. The whole building, in its structural parts, is of brick, and concrete finds its true place in construction, viz, in masses, in the filling in, in the panels of that dome. But the claims of our too enthusiastic concreters are no more foolish and ill-placed than are those of some manufacturers of one clay product or another who would have their material the only one used. The idea, for instance, that a rough hollow tile block can serve, not only as a structural unit but also as a finished well surface, as an ornament, as a roof, aye, even as the mortgage on a house!

All this may seem irrelevant but it is not. The student, I submit, should not only know the relative merits of each system but also the strength, the bias, the objects of the parties back of the systems. In the study of government, for instance, we should not only observe what has been accomplished, the legislative acts, and all that, but we should also know about the parties, the relative influence and power of each, what each has accomplished, and what each stands



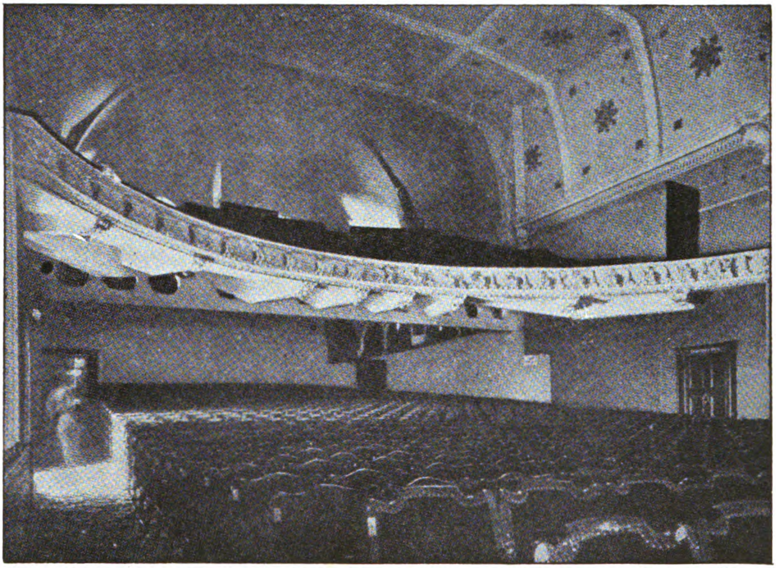


Fig. 41. Reinforced Concrete Work in England
Tynemouth Palace, huge spans in concrete floor construction

for. So with fireproofing. There are two camps, the steel and tile camp and the reinforced-concrete camp—Republican and Democrat as it were—I have not a particle of use for a man who sits upon the fence. I am a strict party man and warn you accordingly. I can see the good in the other party, and I will give it what I deem a fair show, but I am by training, selection, environment, and firm convictions, a staunch Republican and a steel and tile man, and I am very much opposed to the indiscriminate and general use of reinforced-

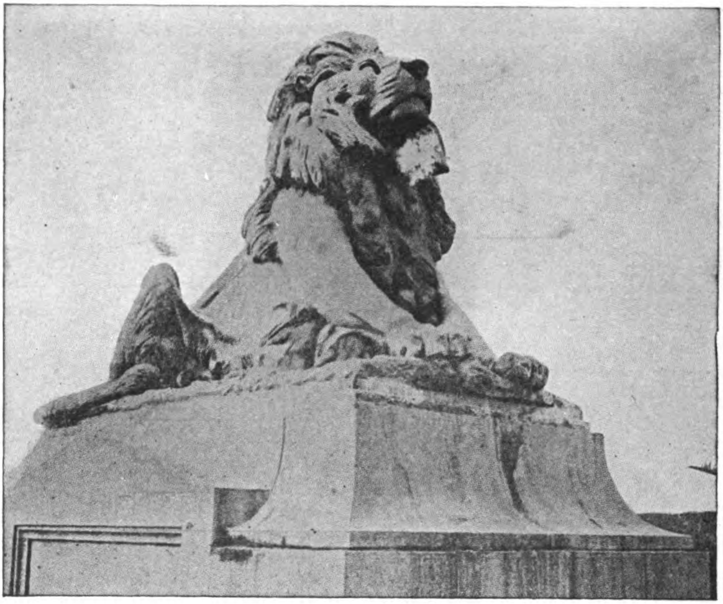


Fig. 42. A Collosal Concrete Lion for a Bridge Approach

It is really a wonder that more such ornamental, decorative, monumental work is not done in concrete, being cheaper than bronze or stone, and just as effective, lasts as well and has the additional virtue of being easily repaired if it should be damaged—something almost impossible to do to bronze or stone

concrete construction, and in favor of limiting its use to experts only and even then under the strictest municipal regulations and inspection.

Much concrete work is done, but in the larger, more important buildings, steel frame and tile construction is still the leader. In New York, for instance, where there are more concrete engineers and systems than anywhere else, it was protestingly claimed by concrete advocates in a recent hearing before the Mayor that 60 per cent of all the fire-proofing done in the city was executed by one tile company, the remaining 40 per cent being divided among the other tile companies and all the reinforced-concrete companies together. The "supplanting" of steel and tile we read about has apparently yet a long way to travel. Even the most enthusiastic votaries of rein-

Fig. 43. Concrete Residence in Cologne
The Germans attempt greater variations in external concrete work than we do. Looking at this and other German designs, freakish in the extreme, we are prompted to thank our stars that we make few such attempts

forced concrete only claim, however, that it is "as good as steel and tile". The only advantage I can see in it is that you can always get cement anywhere and can usually procure sand and slag or broken stone or gravel and light steel sections and water with as great facility,

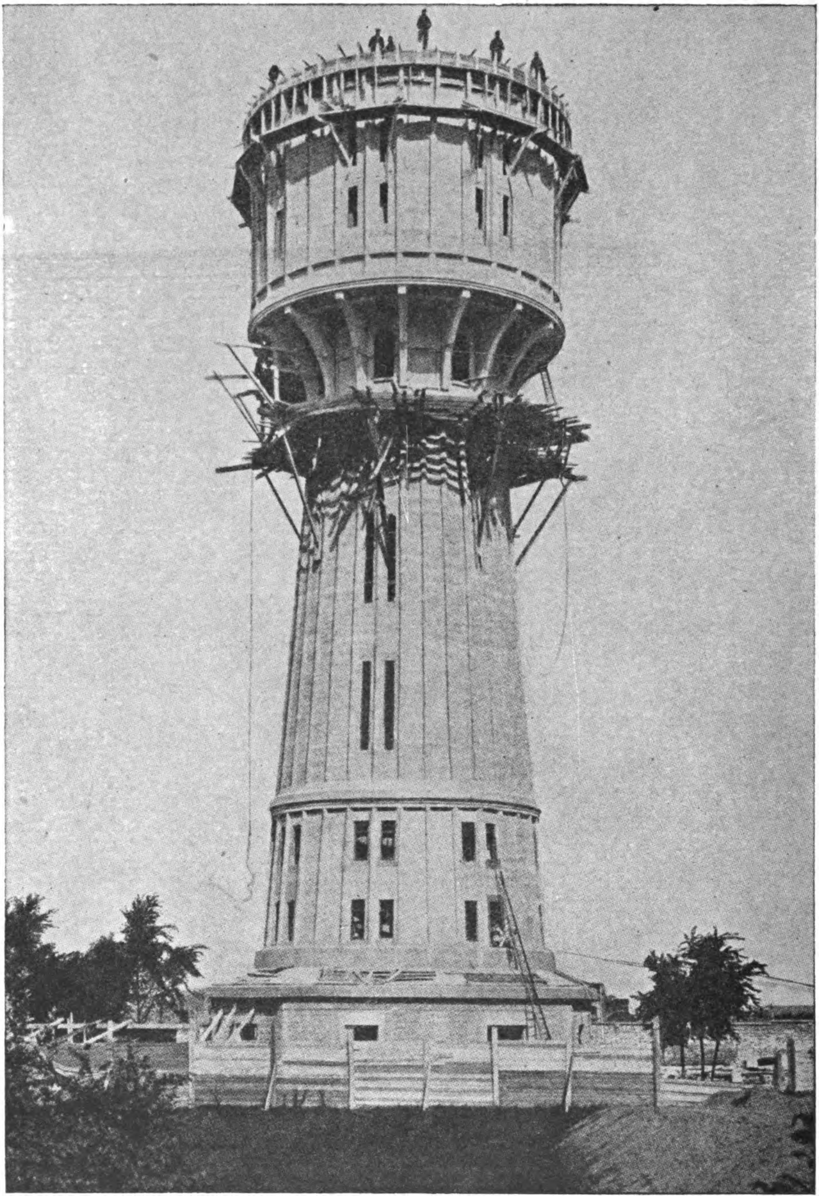
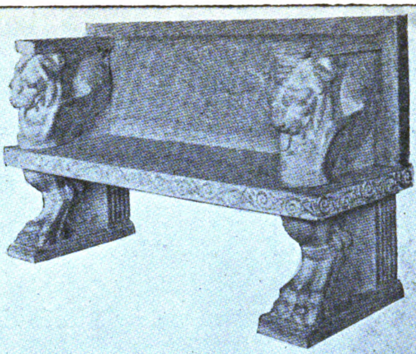
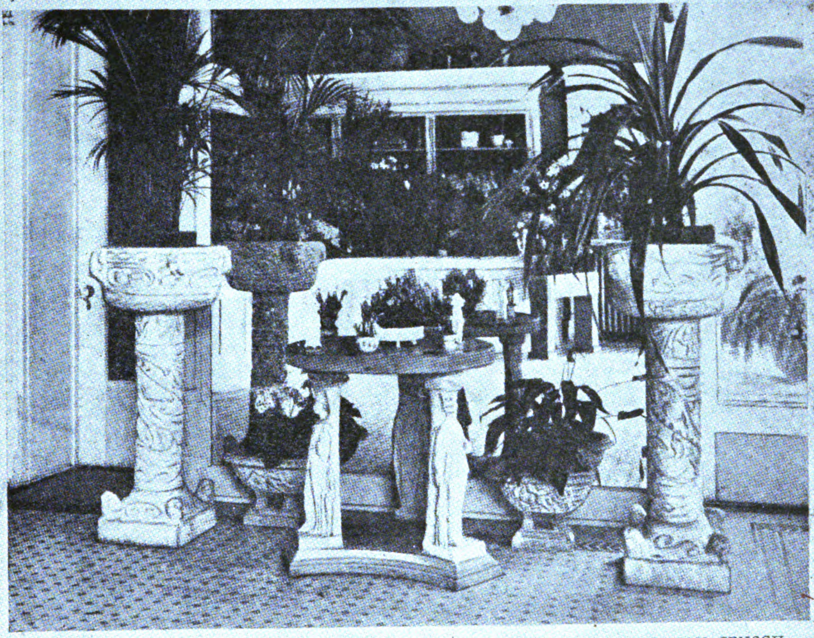


Fig. 44. A Concrete Water Tower
(Not likely to be exposed to fire!)

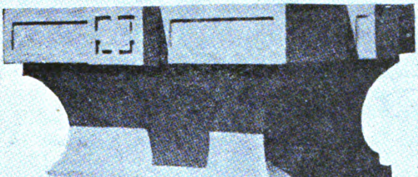
A CONCRETE TABLE OR STAND.
GENSCH STUDIO, CHICAGO.



A CONCRETE GARDEN OR TERRACE SEAT.
GENSCH STUDIO, CHICAGO.



EXAMPLES OF ORNAMENTAL WORK IN CONCRETE. EXECUTED BY MR. HERMAN GENSCH, SCULPTOR, CHICAGO.



A SINGLE DESIGN ESPECIALLY ADAPTED TO CONCRETE. GENSCH STUDIO, CHICAGO.

A CONCRETE PANEL.
GENSCH STUDIO, CHICAGO.

Fig. 45. Admirable Decorative Work in Concrete

No material lends itself so readily to plastic modeling and casting. If care be used it can be kept from crazing in setting, and besides being less costly than terra cotta, it has also the advantage of being repairable after a fire and at slight expense. It can be patched and colored as good as new, while damaged stone or terra cotta has to be taken out and entirely replaced with new.

so that reinforced concrete can be made in any locality. On the other hand big steel sections, beams, girders, etc., and fireproofing tiles are sometimes hard to get and are consequently costly, on account of the haul, far from the big mills and factories of Ohio and the East, so that in the remote South and far West that construction is in some cases really prohibitive. Chas. H. Bebb, the leading

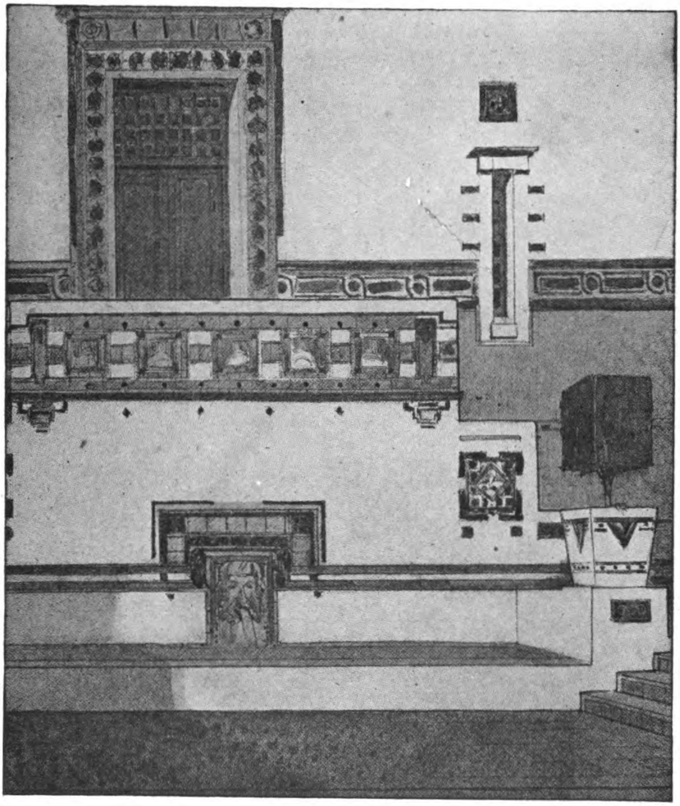


Fig. 46. Effective and Artistic Combination of Concrete and Enamel Tile

architect of Seattle, expressed that phase of the subject most clearly and emphatically in an address given in that city. In brief—

It would occupy too much time and it is hardly necessary that I should go back to the history of the beginning of steel construction. Cast-iron columns and roll-steel beams and girders were used prior to 1888. From this time, however, what is known as the steel skeleton construction has been fully developed, and it has become the vital part of the building, and what every conscientious architect is seeking today is the question of how practically, scientifically and absolutely to cover the "skeleton" inside and out with incombustible material, under widely varying conditions and contingencies.

There are two classes of use for burned clay in fireproof buildings: one when used constructively under pressure, and the other when used as a non-conducting and structure-protecting material. In the first case it must sustain strains and at the same time resist heat for its own protection and in the other it acts only for the protection of the steel members of the building. In some, it performs both offices, as in the case of floors and roofs; in others it is inert as used in protecting steel columns and girders.

In considering the use of burned clay products for exterior walls, we have structural terra cotta and brick, or a combination of both, to select from. Experience has taught us that the employment of these materials for protecting the steel framework of the modern building is as essential as the foundation and framework. The modern high building has a function to perform outside of its own structural integrity; in case of a conflagration it must serve as a check to the onward rush of flames and superheated air. The proper anchoring and tying of the fireproof material to the steel frame to prevent the building from shedding its masonry work is one of vital importance. Terra cotta in combination with bricks is the lightest building material to be had that satisfies all the requirements of modern office buildings. These raw materials come in convenient shapes and are quickly and easily handled, an essential factor these days in putting up expensive buildings.

A building covered with structural terra cotta is the fireproof wall that can be placed in the path of a conflagration, and, on account of its comparative lightness, it has become almost a necessity in twenty- and thirty-story skyscrapers. From the architectural point of view there is no material which offers greater possibilities of beauty and harmony of coloring as well as such virtues as strength, durability, lightness and great fire-resistance. In reply to a communication as to the life of a well-designed and executed building of the steel-skeleton type—the question having been brought up by the Board of Regents of the University of the State of Washington—Irving K. Pond, the President of the A. I. A., considers that they would virtually be in as good condition structurally at the end of a fifty-year period as at the beginning. New methods of damp-proofing make the protection of the steel frame altogether practicable, and the glazing or under-glazing of terra cotta well adapts that material to withstand the ravages of frost and dampness.

Coming to the question of interior fireproofing, I again affirm that hollow clay material of what is known as porous terra cotta is the best material for floor construction yet devised, which equally applies to partitions and roofing. As essential as the proper protection of the steel frame in the outside walls is the proper construction and the use of right materials in the floor construction and protection of the interior columns.

The poorest form of construction for forms is the reinforced concrete where the aggregate is composed of gravel. Professor Woolson states, after exhaustive tests, in Section 4 of his report as follows: "Concrete made with gravel aggregate is so weak after the fire test that it is practically impossible to test its strength". James Sheppard, in a paper read before the International Congress at Milan, Italy, says: "It has been conclusively proved that concrete made with gravel aggregates is especially unreliable under the action of fire, and the same may be said of other dense material. Aggregates that have passed through fire and are of a porous nature, such as broken brick clinkers, clean coke breeze, offer the greatest resistance to fire".

It would merely seem common sense to prohibit the use of gravel reinforced concrete for floor construction in the modern skyscraper, and where, on account of cost, this style of floor construction is adopted, only burned

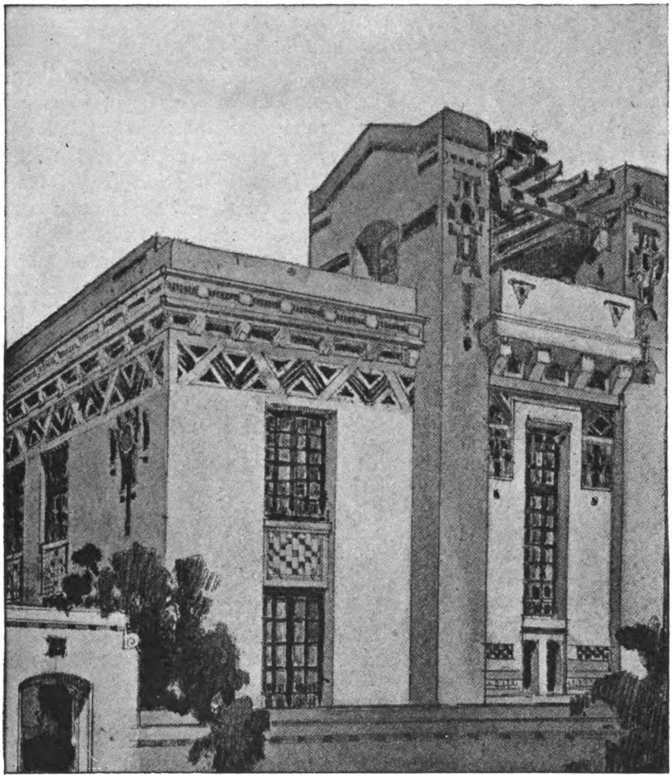


Fig. 47. Architect Wynkoop of New York has Shown Himself a Master of His Art in This Work

Usually the idea prevails that concrete has to be designless, ugly strictly utilitarian—probably because engineers generally *design* it—while, as a matter of fact, the material being so very plastic and adaptable, beautiful results may be obtained, as in this case, and probably at less cost than in any other material, by understanding the medium and handling it intelligently rather than endeavoring only to imitate some other material entirely foreign to it

clay products or materials that have been through the fire should be allowed in the matrix.

Porous terra cotta should be the only material allowed for fireproofing columns, and the greatest care should be used in the method in which material is placed in the building. It is unnecessary that I should speak on the subject

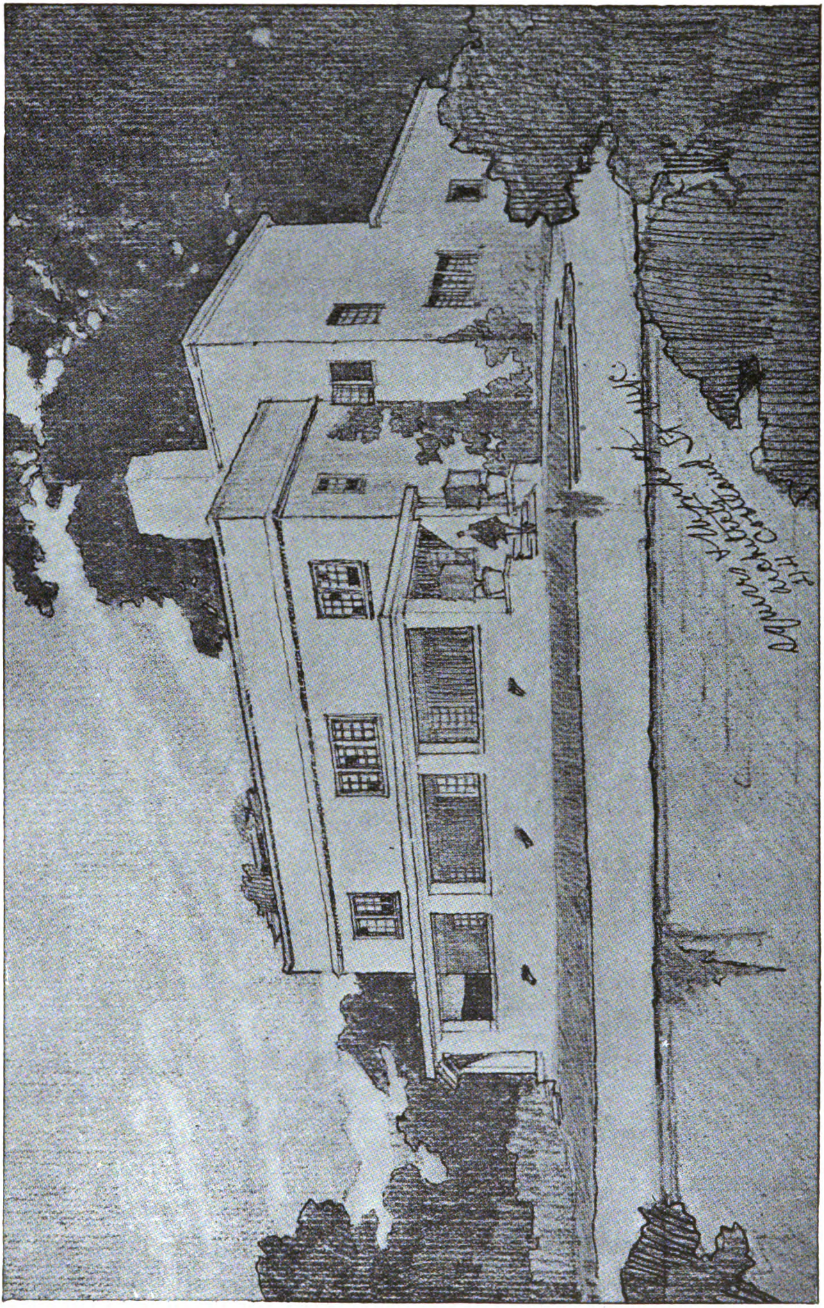


Fig. 48. A Concrete Block House at Lake George, Rather Artistic

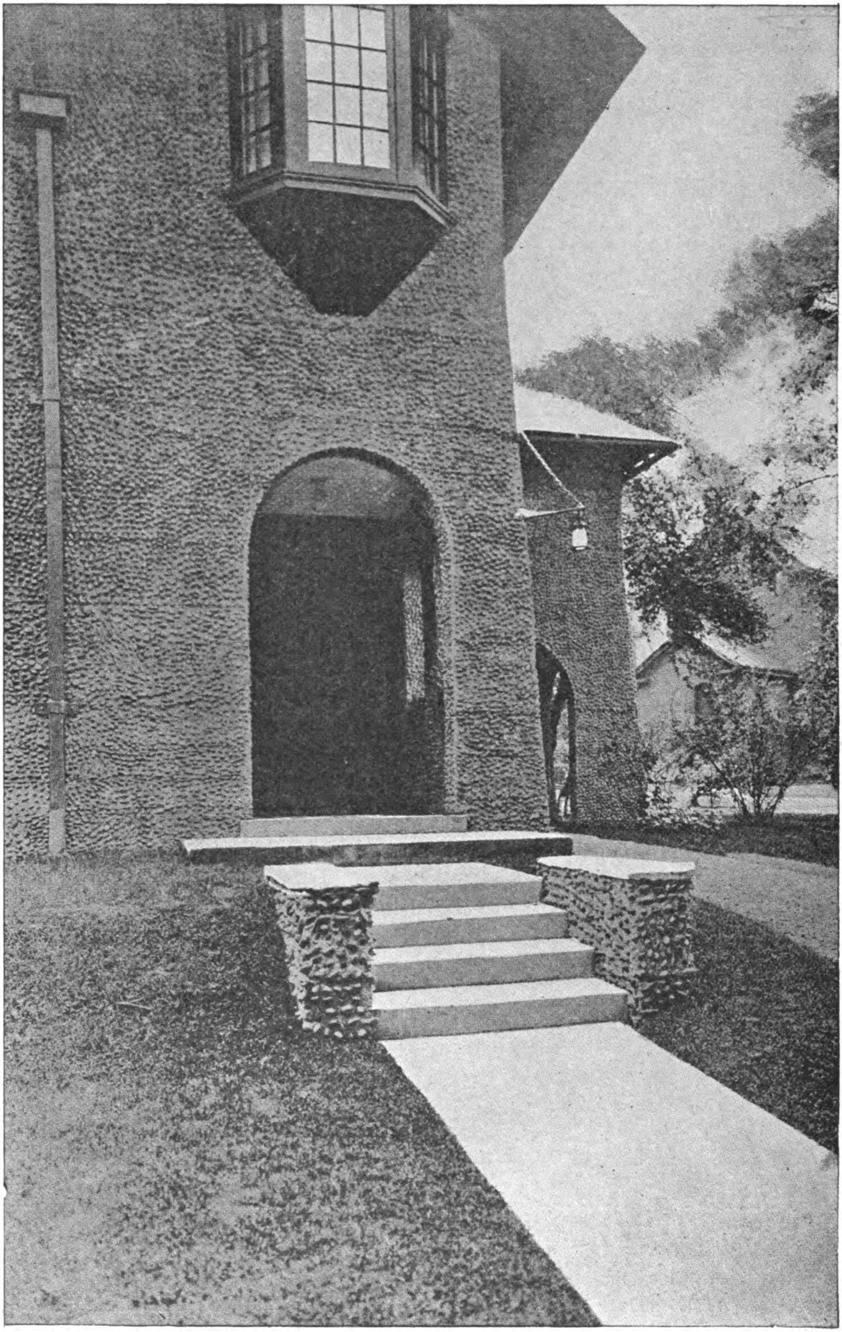


Fig. 49. Artistic Concrete Work

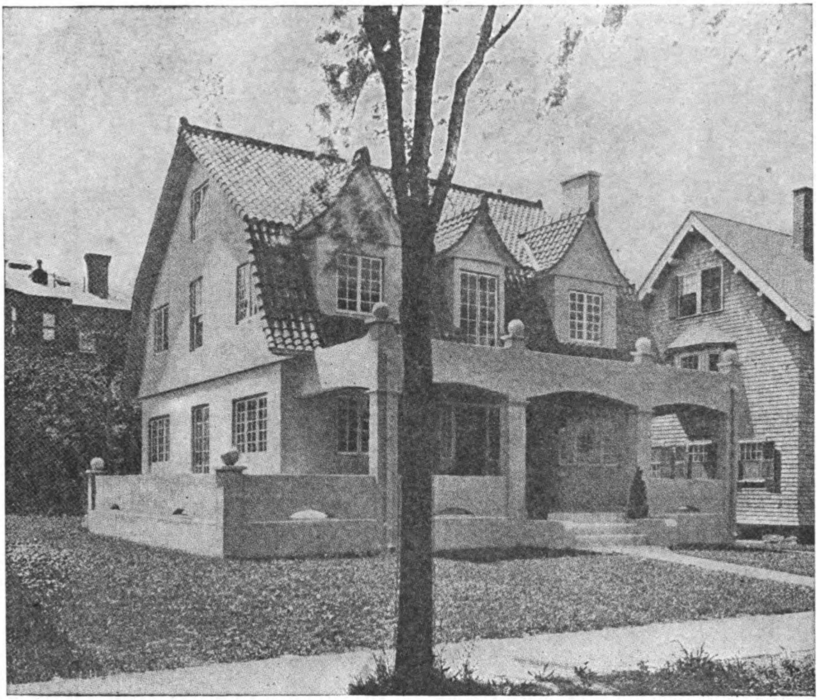
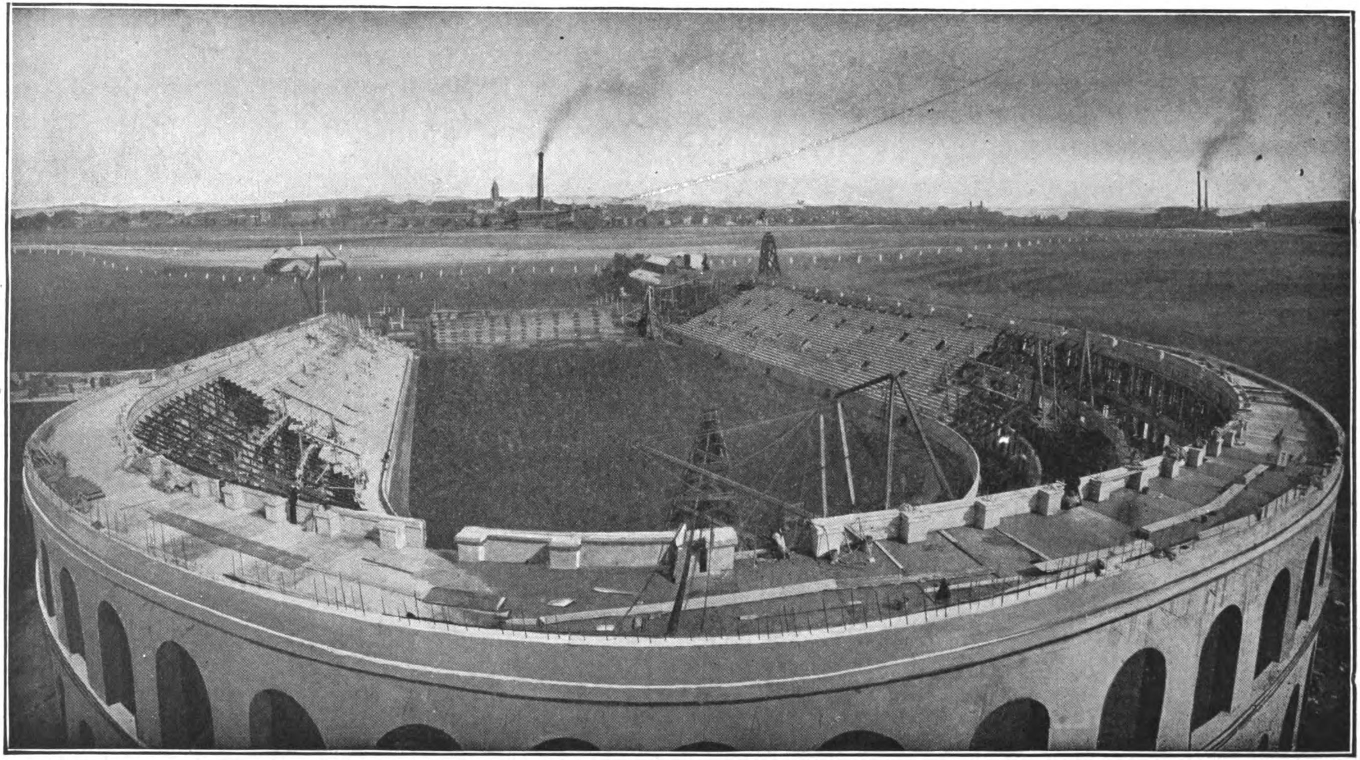


Fig. 50. Concrete House

of partition tile, roofing, furring tile. They are so abundantly superior to any of their popular substitutes that words would be wasted. The fact that they are not procurable in this market at reasonable rates appears to me the sole reason why they are not as extensively used here as they are in the eastern states. But I want to say to you that the demand here is among architects endeavoring to do the best class of work, and the field is open for the clay workers of the greater Northwest to fill.



STADIUM AT HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Built entirely of Reinforced Concrete.

Reproduced by Courtesy of John Wiley & Sons, from "A Treatise on Concrete, Plain and Reinforced," by Frederick W. Taylor, M. E., and Sanford E. Thompson, S. B.

FIREPROOF CONSTRUCTION

PART III

A FIREPROOF BUILDING IN DETAIL

Outside Walls. If the building is to be in a congested, hazardous district, surrounded with combustible buildings, then should the outside walls be of brick, good, hard-burned, common, clay brick in preference to the fancy pressed and moulded kinds—I abominate the sand-lime kind. Concrete brick will give a good account of itself in a fire. Granite, marble, lime and sand-stone are but little better, one than the other. If the building is isolated and there is no danger of attack from the outside, then granite, marble, or stone is all right, but in a fire of any intensity two or three inches of surface will fly off, chip, spall or actually (in granite) explode; mouldings are destroyed and such stone work has to be entirely done over again.

If there should happen to be a pretty hot blaze in any room the window lintels and jambs of the stone work would go. This runs counter to the general idea that if a building is to be the least bit monumental the first thing that suggests itself is granite. It is associated in our minds with all that is enduring, everlasting; and it *is* a most lasting material under all other tests than fire, but in that it acts about as badly as any material can.

Concrete wall surfaces spall and crumble under fire, but to a far less extent than do marble and granite and stone, and it has the virtue of being easily stuccoed or plastered over or patched so as to be nearly as good as new after a fire and at far less cost than for repairing a stone wall.

Ornamental Surfaces. Ornamental surfaces, carvings and mouldings, cornices, etc., had far better be of terra cotta than of stone or marble. But so many terra cotta manufacturers are making their ornamental pieces extra thin, sharp angled inside and other-

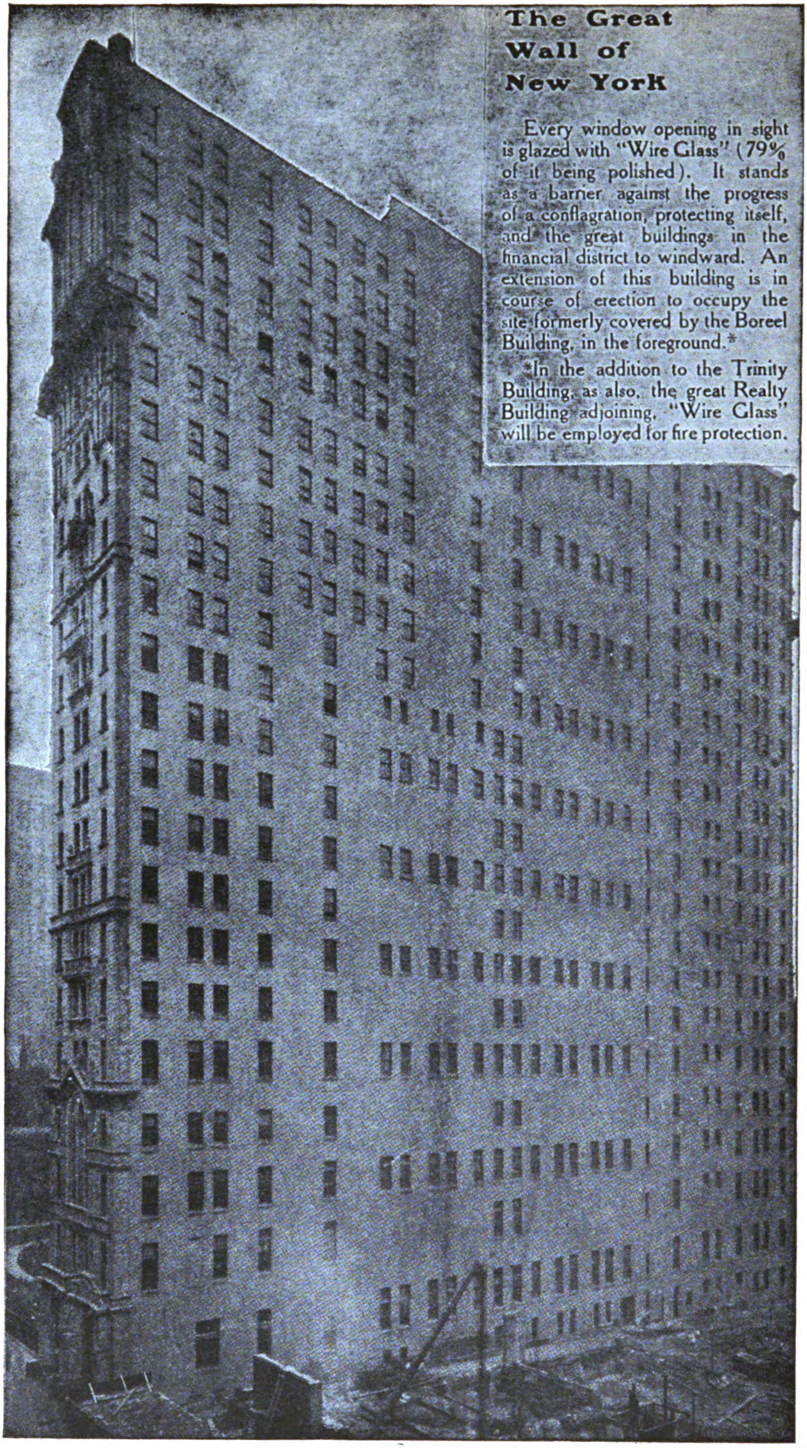


Fig. 51. The Great Fire Barrier in New York City

wise so defective that in several fires, noticeably at Baltimore and San Francisco, much of it gave a rather poor account of itself. A shame, too, for with a little care it could be made, and in most cases is, the ideal ornamental medium. It is somewhat of a surprise to me that cement is not more exploited for ornamental work in lieu of stone and terra cotta. It can be made to look as well, is so plastic and easily moulded at trifling cost, and has the virtue that if damaged by fire it can be patched and repaired as good as new without delay and at insignificant expense.

Galvanized iron and other metals used in cornices and external ornamental work are sure to be twisted and warped and "thrown" in fire. They have the questionable virtue of being easily replaced at no great cost and their destruction does not affect in any way the stability or safety of the structure itself or of its contents. But it also must be remembered that this argument is a species of sophistry, which we could apply to very many parts of a building. The really fireproof building is one in which the fewest parts can be damaged to any appreciable extent.

Wall Openings. What is the use of building resisting brick walls in the hope that fire will attack them and considerately not seek ingress via the easy window route? What protection is a wooden sash and glass window? Seventy-three per cent of all damage done by fire to buildings other than those in which it originates is attributable to improperly protected exterior openings, windows, and doors. More than 48 per cent of the *entire* fire loss of the country is directly traceable to lack of proper window protection.

Door and Window Shutters. All sorts of rolling steel shutters, automatically closing iron shutters, sliding shutters, and window- and door-protecting devices are on the market. Sometimes the "automatic" device works and sometimes it does not. If we depend upon such shutters being closed by hand we know that man is fallible, that watchmen do not always watch, and that even if closed an intense fire may twist and open them and let fire in. They have done good work but a door or window shutter made of two thicknesses of boarding with tin between and covered with tin, is the best of shutter protection. The wood may become charcoal in a stiff fire but the shutter will hold its place and do the protecting all through that fire. I have had the greatest satisfaction with those wood and tin shutters hung to slide in grooves, as a guillotine, and held in place by a fusible plug or even a cotton cord that is severed by the slightest blaze so as to let the shutters down tight as wax.

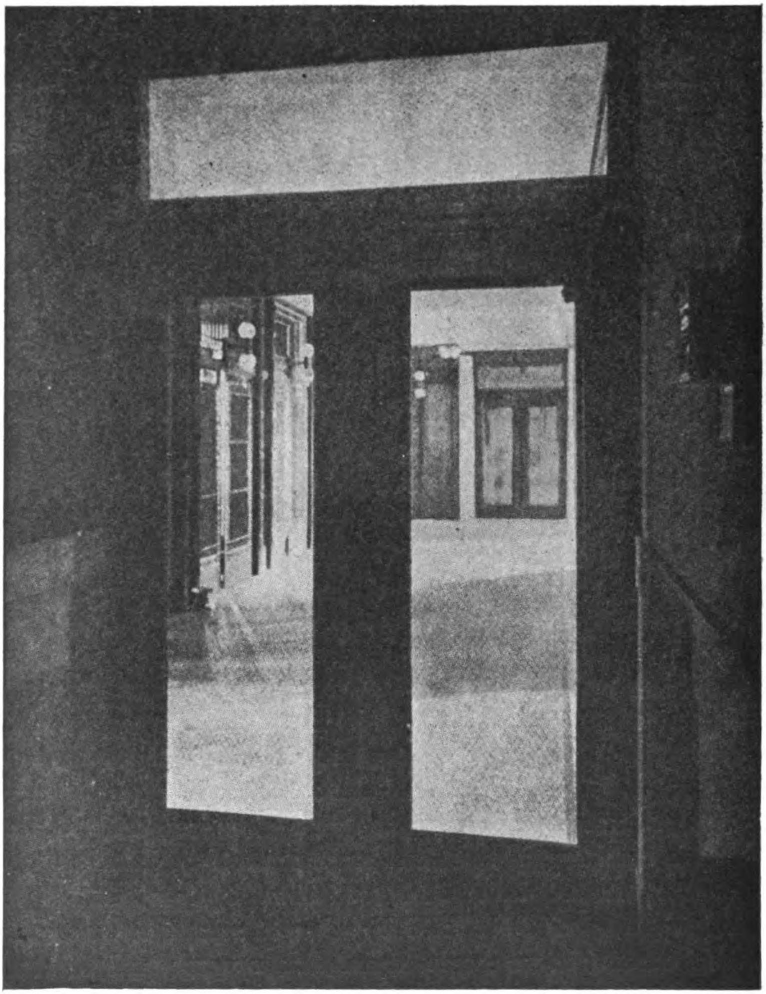


Fig. 52. Fire Doors (Wire Glazed) at Frequent Intervals are a Great Protection

The very best of protection is *wire glass in metal cr asbestos sash and frames,* and plate glass is better than common glass. In a very hot fire the glass will crack and break but the wire holds it in place and while one might imagine fire would strike through the broken fissures it does not. Wire glass has saved millions of property in the few years of its use. Like the wood- and tin-shutter it has to be replaced after a fire for appearance' sake, though even in

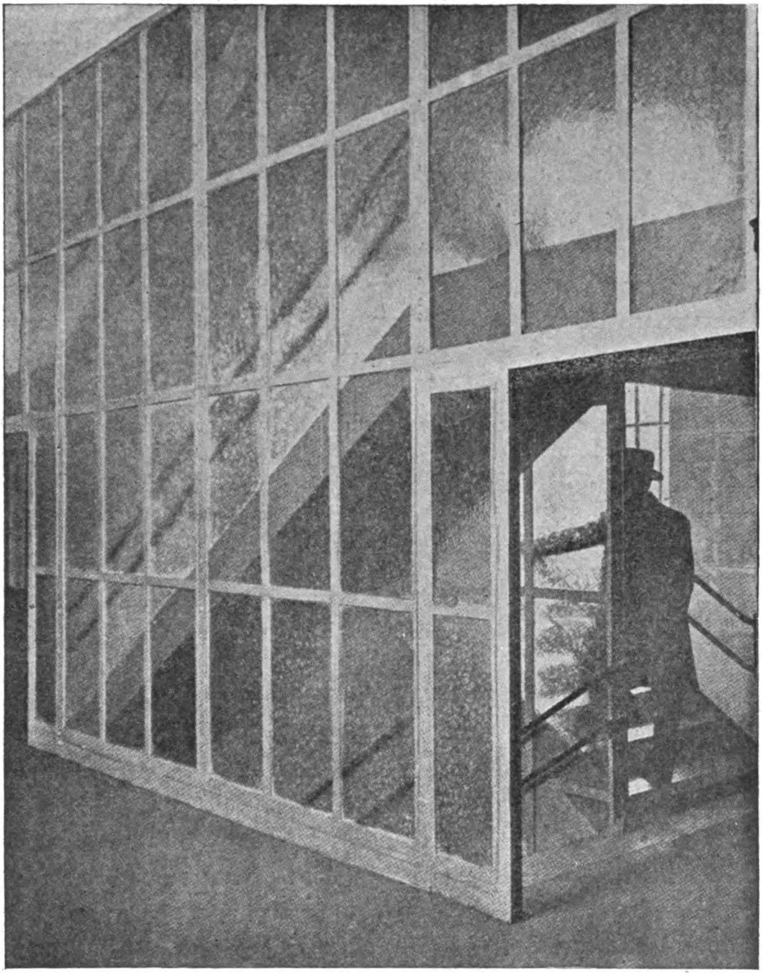


Fig. 53. If Brick or Tile or Concrete Enclosing Walls to Stairs and Elevators are Undesirable, then Install Frames and Wire Glass

its broken condition it will withstand a second and a third fire. Now, even in wire glass, there are degrees of excellence. The ordinary make is a layer of molten glass laid upon a moulding bed, then the wire placed upon that surface and another layer of glass over the wire. Rapid as the process is there is a brief interval for the cooling of the surfaces and a slightly imperfect adhesion results. In an intense fire these three layers have a tendency to part and that causes much of the crackle. A *solid wire glass* made by introducing the wire into the molten glass at one operation, will stand a greater heat without crackling and will remain in better shape to resist another and still another fire.

A chemist has lately achieved a perfectly transparent, heavy plate glass so annealed that it will stand 3,000 degrees of heat. That would place it outside of the possibility of fire damage; but, like radium, for instance, it is so costly as to be absolutely prohibitive and, according to this chemist, could only be made in small pieces. Yet he has pointed the way, and the time may not be far distant when we will have transparent parts of buildings of as great strength and resistance to fire as the solid brick walls themselves. Indeed, who says we may not some day do away with "windows" and have transparent walls that may be curtained where privacy is desired?

Skylights and Transoms. Nor has anything better than wire glass and metal framework—with as little of the latter exposed as possible—so far been devised for skylights and for "borrowed" lights in partitions, transoms, etc. Wherever you must have light or any opening, protect that opening with wire glass. Let the whole of the outside of a building be brick wall and wire glass and with as little of exposed metal frames, mullions, transoms, and such details as possible, and you may rest in perfect safety insofar as external attack is concerned.

It is the fashion to advise wire glass only for the windows on narrow alleys or for windows above a lower and combustible building. In those positions it is absolutely necessary; but you may judge what a poor policy it is to dispense with the wire glass in the windows facing the street, when I tell you I have seen fire jump across a street 60 feet wide, go straight through the windows, and destroy the building. That was not in a great conflagration either. In Baltimore and in San Francisco I have seen evidences of fires actually leaping across spaces 100 and more feet wide. Windows right at the ground level, like store windows, suffer least from fire across a street. If the opposite buildings are five and six stories high, your windows above the sixteenth floor suffer little, the main attack being usually from the third story up to three or four stories above the opposite building.

Roofing. Common sense, that most necessary of fireproofing requisites, must tell you that shingle roofs burn easily, for sparks set them afire at a very long range; tar and pitch composition, if particularly well graveled, will not yield very quickly to sparks, but will melt and run off under moderate heat; slate roofs pop and break much as granite does under heat, though no mere sparks may

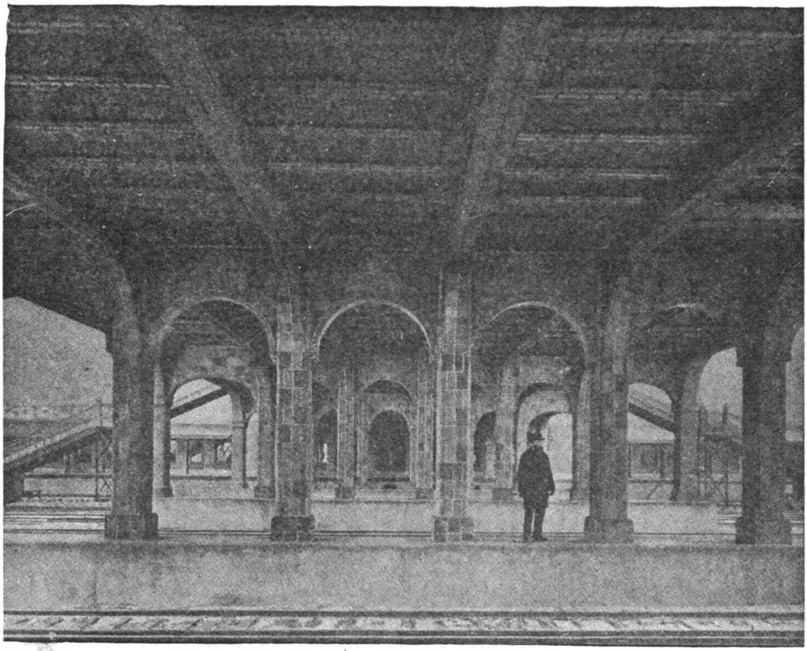


Fig. 54. A Tile Viaduct in Chicago

affect them; copper, tin, or other metal is not affected by sparks, but will buckle and pull under heat; lead will melt and a shower of molten lead is not conducive to the best of humor on the part of the firemen; asbestos and cement shingle is cheap, looks just like wood—a great virtue to many—is as easily put on, and is splendidly fireproof; a heavy roof (clay) tile is the only thing better and more fire-resisting than asbestos shingle, but, too, it is the most costly roof of all.

Piers and Foundations. All piers and foundation work had better be of concrete. In most of such situations, in the ground, for example,

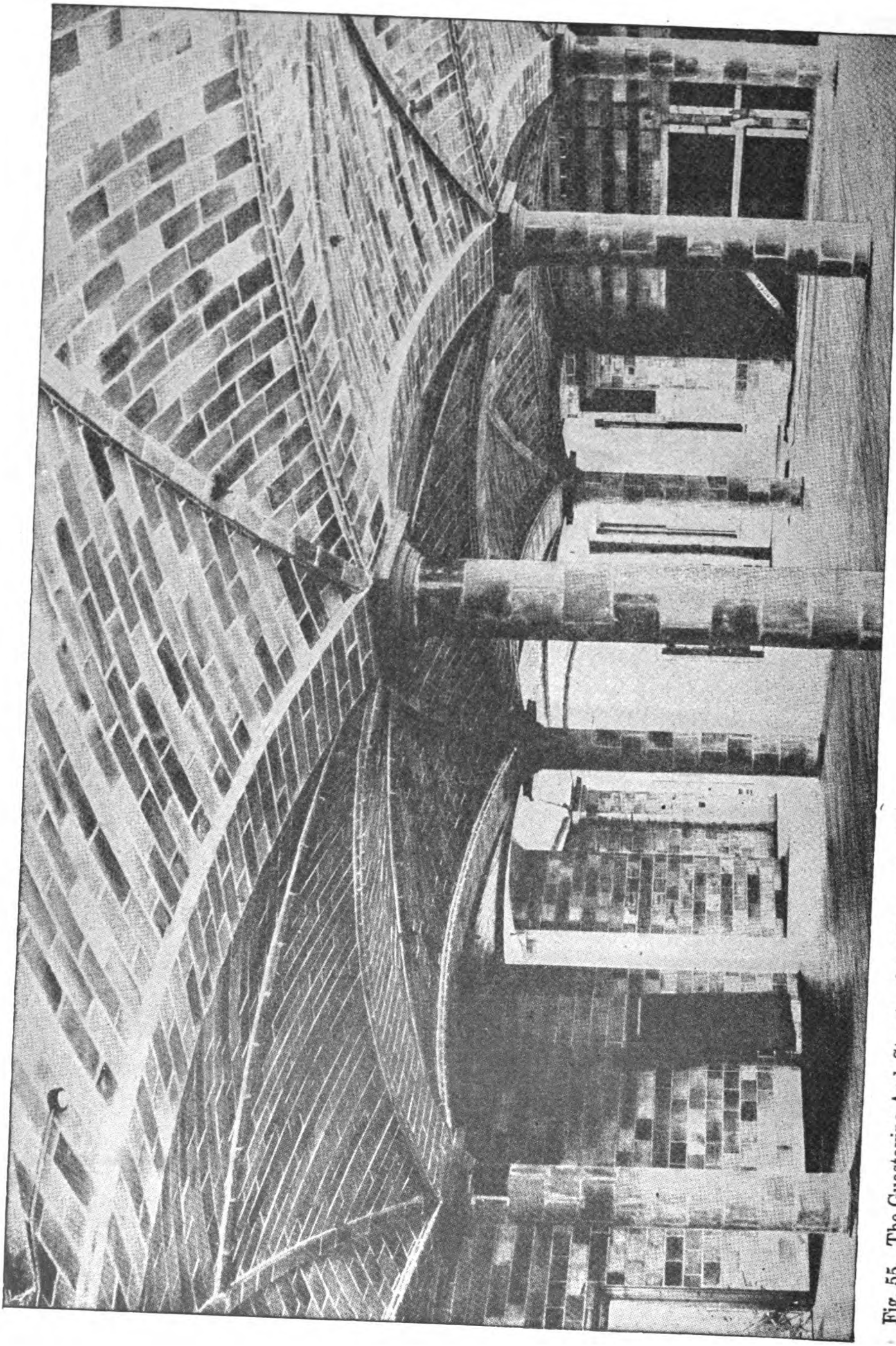


Fig. 55. The Guastavino Arch Structural and Decorative Tile Construction—An effective reversion to its first principles of groined arch construction

fire cannot possibly get at the work, and where firè can reach it, as in furnace rooms, etc., it should be protected with a furring of tile or with a layer of brick, or 2 inches extra of concrete that may be damaged without affecting the stability of that pier or wall.

Structural Parts. The skeleton, the structure proper, I contend, had, better be of steel, while others with equal insistence contend for the skeleton of reinforced concrete. In either case every bit of that structural support should be protected from fire by tile or concrete. The floors should be of brick, tile, or concrete, the partitions of tile, concrete, wire lath and plaster, or plaster board, with the preference in the order given. All the steel work should first be coated with cement "grouting" (cement and sand) quite thin so that it may get into every interstice and thoroughly protect all the steel from rust. If concrete is used for the fire protection make it thin enough so that there will be no voids against the steel and under no circumstances use cinder concrete where it will be in contact with the steel. Concrete of slag and clinker, broken brick and terra cotta, crushed trap, granite and lime stone and last gravel, is the order of fire resistance.

Tile Protection. In tile work, porous terra cotta blocks only should be used (the clay is mixed with sawdust that is burnt out in the kilns where heat of 2,600 degrees and over is maintained). The dense tile breaks more easily, contracts more unevenly and is in every way less desirable.

For ceilings, domes and broad arched surfaces there is a slab tile —Guastavino system—of exceptional beauty, and though apparently light, it is a construction of the very greatest strength, a finished structural tile splendidly adapted to church groining, bank and other domes, viaducts, etc., where plastering finish would be out of harmony with the heavy monumental character of the rest of the work.

Fire will expand all tile covering and if there is no room for that expansion at the top it will "throw" the tile out and attack the steel. There should always be a space left open at the top of the column at each story, a wide joint filled with asbestos felt. This will not burn out and the expansion of the tile will merely compress it and entirely close that joint.

Floors. The floors should not be cut and butchered for pipes and ducts, these being laid on top of the tile or concrete floor construction and embedded in the filling concrete or "built-up" false tile filling upon which is laid the finished surface of the floor, a cement, tile, or other fire-resisting material. Building regulations permit in buildings of limited heights, wood-finished floors on wooden sleepers, buried in the concrete. It is bad practice for it puts just that much wood in a building, fuel for fire. However, being embedded in concrete, it burns slowly and is not nearly as bad practice as wooden wainscoting or wooden ceilings.

In stores or warehouses where the basements are to be filled with goods, and even where a sprinkler system is installed, it is well to have capped hose-holes in the first floor through which water may be hosed into the cellar at different points without the firemen having to go into the cellar.

The custom of having great open, galleried courts in stores and office buildings is destruction-inviting. Fire's tendency is ever upward and in such a store it will fairly leap from cellar to attic, carried by the great mass of combustible goods usually found in stores. Each story should be an absolutely isolated unit and one of not much over 5,000 square feet—that is about the maximum of unbroken area that can easily be managed. Floor areas larger than that should be cut up by fire walls and doors.

External Light-Courts. If external light-courts are designed, the walls should be thick enough to protect the steel and stand the blast of fire from a room opposite and every window should be metal-sashed and wire-glazed. External light-courts should be upon one's own premises or facing the streets, rather than facing and opening upon a neighboring property. A joint light-court or one abutting upon adjacent buildings is an extra hazard.

Stairs and Elevator Shafts. The stairs should be in an enclosed part, a stair hall, and with automatically closing fire doors at each story, doors which open into the stair hall but which are kept closed on a spring or other device; and severe penalty should be the portion of any one blocking such a door open.

In the same manner elevator-shafts should be enclosed in fire walls and with self-closing doors at each story, or else with iron frames and wire glass. The great principle is to keep fire from communicating from one story to another.

Halls and Exits. In long halls, such as are needed in hotels, for instance, self-closing fire doors like those here described, placed at intervals, are a great protection. Main stairs and elevators should always be planned to debouch on the first floor, right at an outside door or into a passageway communicating directly to the street and not having any openings thereto from stores and basements. The object is to provide *direct* exit to the street. What is the use of bringing people in safety down from the upper floors to put them out into

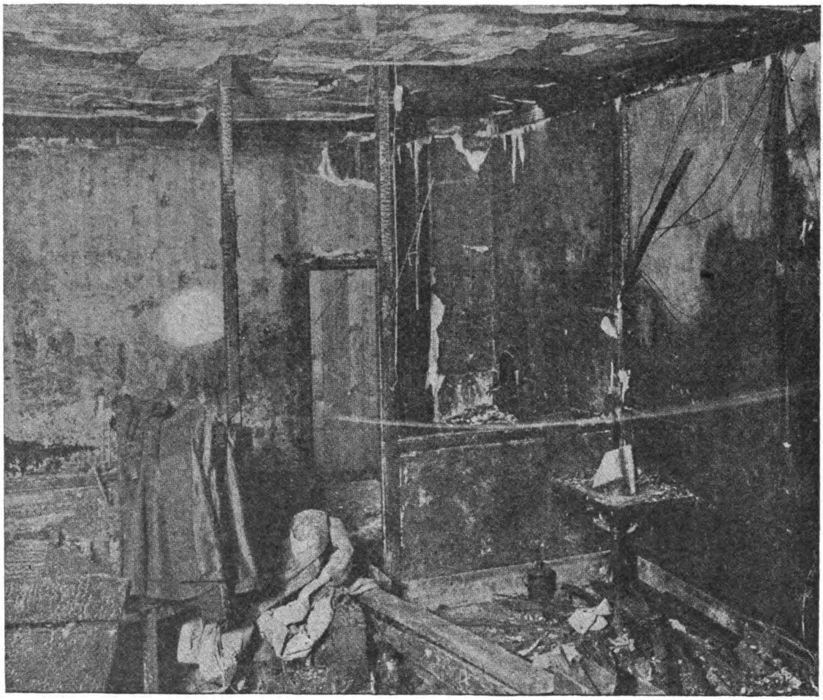


Fig. 56. A Hot Fire in One Room of a Chicago Fireproof Building
The fire was held in that unit and did no damage to any structural part.

a burning first floor to grope around trying to find the exit to the street? Make it direct and fireproof so that people leaving the elevator or stairs can do nothing else but get right out into the street. Remember that however many fire escapes are provided, the tendency of people will always be to escape via the route they came in by or use daily; for this reason the importance of making that route the safest and most available way of getting out is evident. It is remarkable, however, how quickly people learn to have confidence in a reasonably good building. Sometime ago there was a fire in a well-built Chicago office building. It damaged some ducts and several rooms, the whole fire department was there and much hose was stretched and there was great excitement. Of course many occupants hustled out, but tenants in surprising numbers went on with the routine of business and calmly looked at the crowds and firemen. They realized they were perfectly safe—that the building could stand anything but a conflagration test.

Shafts. Pipes, ducts, wires, etc., should be carried up vertically in fireproof shafts with fire doors at the stories where openings are needed. It is surprising to find so-called "fireproof" and expensive buildings with such ducts made of wood, continuous boxes from cellar up and as effective in carrying fire all through a building as a wick in carrying oil to a flame in a lamp!

Use of Wood. *Avoid wood as you would a pestilence, a quarantined house!* It has been common where wood-finished floors are used, to lay such a floor over the entire story and then build the tile fireproof partition wherever needed on top of that wood floor. And also it is quite customary to build into such partitions, wooden frames, jambs, and lintels for partition windows. Then in a fire, the wooden jambs, frames, and floors would burn away and let the partitions down. It is necessary that such partitions should have suitable foundations, just as any other wall should have. Set them upon the solid tile and steel or concrete floors; do not wedge them tightly against the ceiling but leave a small open joint of asbestos felt at the top for expansion under fire; and use metal frames and sash and wire glass for all partition lights.

Interior Woodwork. The tendency to use fancy and expensive woods for interior decoration is ingrown, and it takes an effort to get it out of our systems. A "mahogany" finished parlor, or an oak wainscoted dining room, represent the top notch of most housewives' ambition, and it seems rather cruel to deprive them of these apparently harmless luxuries. Fine marbles can also most cruelly suffer if a fire attains any fierceness in a room, and, although it will not burn as will the wood, it will have to be entirely replaced. Therefore, whatever there has to be, let it be of metal—metal doors, metal frames, etc. A wood-filled metal-covered door that is particularly good and not costly is on the market. But if you *must* use wood doors, for instance, make them with as little framing and ornament about them as you can.

General Fireproof Features. Everything burnable or damageable you put into or about a building lessens its *fireproofness* just that much. If you get enough of it in, you jeopardize even the fire-resisting structural parts. One is not justified in calling a building fireproof if, after a surrounding conflagration, it costs 40 per cent to 60 per cent of its original cost to put it in habitable shape. Perfection is not a usual accompaniment to things mundane, so an absolutely perfect building is a rarity—indeed, I know of only the one before mentioned, the Underwriters' Laboratory at Chicago, in the entire country—but allowing a good margin for human fallibility and all that, we are justified in demanding that a fireproof building be done so well that in the supreme test—a conflagration—not over 10 per cent of its cost value will be needed to repair it and that only in its decorative, non-structural parts. The structure itself should be intact, and the building should provide absolute safety to all life within it and to the major part of its contents. If a fire is of internal origin, then that building should be so cut up and the units so protected, that life is perfectly safe in it; the occupants of one part need not even know there is fire in another part and 85 per cent of the contents of that building should be absolutely safe.

Few terms in the English language are more abused than that self-same "fireproof". Hotel keepers, whose buildings are veritable tinder boxes, paint those fire traps with some advertised *fireproof paint* and then in the most perfect effrontery proclaim those buildings as absolutely *fireproof*. Storage warehouses are also arch offenders. Just about one in ten is even moderately safe, but was there ever one that did not proclaim in letters six feet high that it was "absolutely fireproof?" The official labeling of buildings as to their class of construction, as has been already described and advocated, would stop that false pretense and effectually put the too-confiding public on its guard.

Wall Finish. To go on with our ideal building, use good *plaster*. Well applied to tile or concrete, it will fill all cracks and be just that much more protection. In a hot fire and if water be thrown on it, it will crack and fall off in big patches but it will have protected the

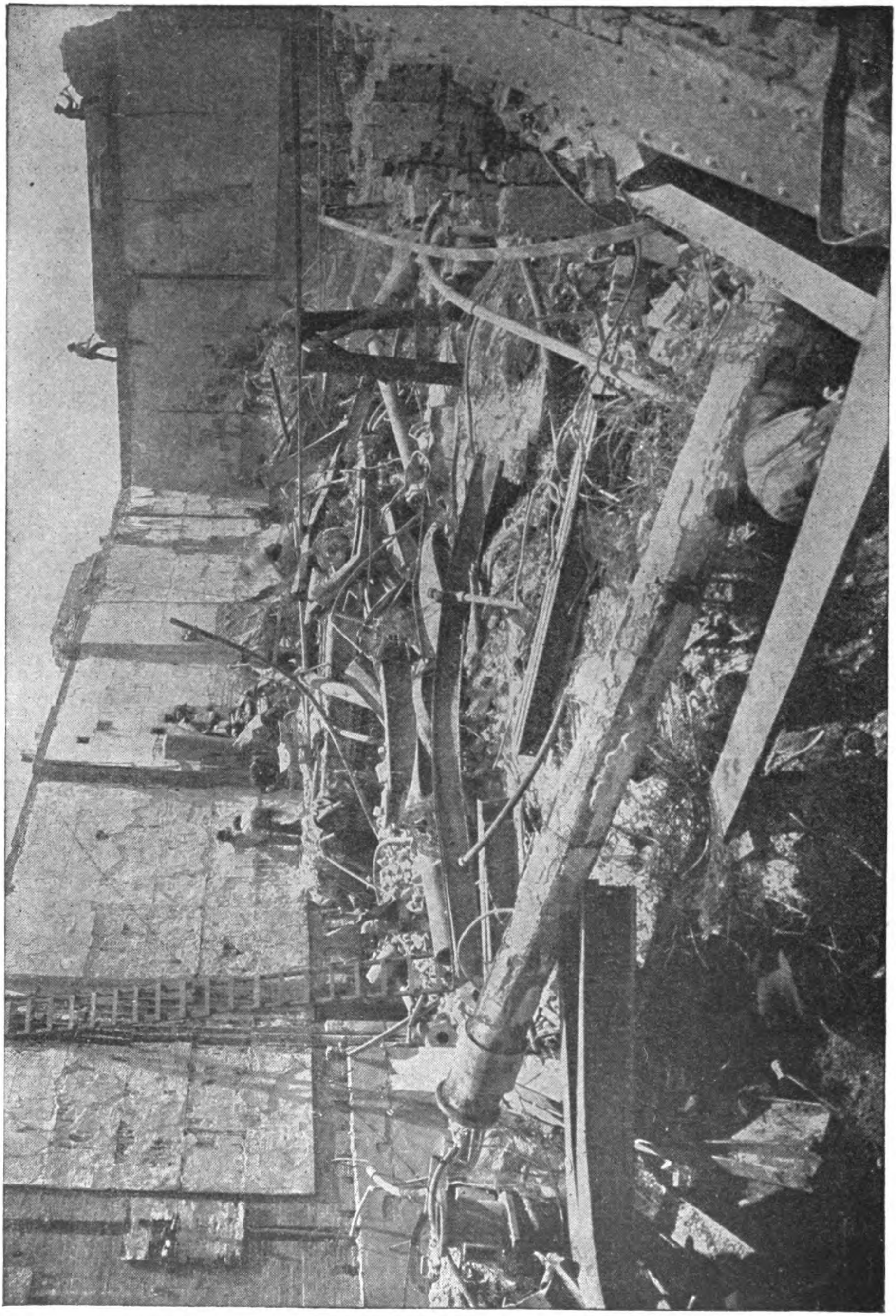


Fig. 57. What is Left After a Fire in a "Partially Fireproofed" Building
The wood portions entirely consumed and the steel and iron in a scrap heap.

structural parts just that much from the first hot blast. You cannot depend upon it for complete fire protection—although many ignorantly do so—but it is helpful. Every coating of an unburnable, even though damageable material which is put on over steel or concrete is just that much additional protection. A good overcoat will keep you warm and protect you from the snow; an additional coat, even if only of alpaca, will make you some warmer and keep the snow from wetting the overcoat.

Then let your decorations be in colors. A good artist will make your walls and ceilings beautiful, symbolic, warm or cool, anything your fancy may demand, and much more effectively and at far less cost than your decorator can do with expensive woods and precious draperies and hangings. If you have the money, indulge in grand mural paintings, plastic ornament, panels and gildings and mouldings; if only moderately circumstanced, judiciously paint your plain walls and ceilings and be happy and safe.

Furnishings. In furnishing use the same good judgment. What is the use of filling a house with heavy wooden bedsteads, cupboards, and what not, and hanging endless curtains and draperies at every door and window? Greater simplicity is far more attractive and much safer. Think of the many serious fires and accidents to people you hear of that have been caused by curtains blowing against a gas jet or being ignited from striking a match to light the gas or a cigar. There are all kinds of furniture—office and store and house furniture—made of metal, pretty, dainty, light, incombustible, and in every way superior to wood, while being, in the long run, no more expensive.

Such, briefly, are the general principles of fireproof construction and their application. Use nothing actually combustible; if you use anything incombustible but damageable, then protect it with material that is not damageable or that, if it be damageable, will protect it and be easily reparable afterward.

Special Requirements. *Theater.* Each class of buildings, as to its use, has, of course, requirements of its own. A theater has infinite details. The proscenium division must be an absolute cut-off; a steel and concrete or asbestos sliding curtain is the best; all of the stage that can be, should be of metal and brick; there is bound to be much scenery and burnable property, so that the stage should be really a great flue with an easily opening skylight, automatic pre-

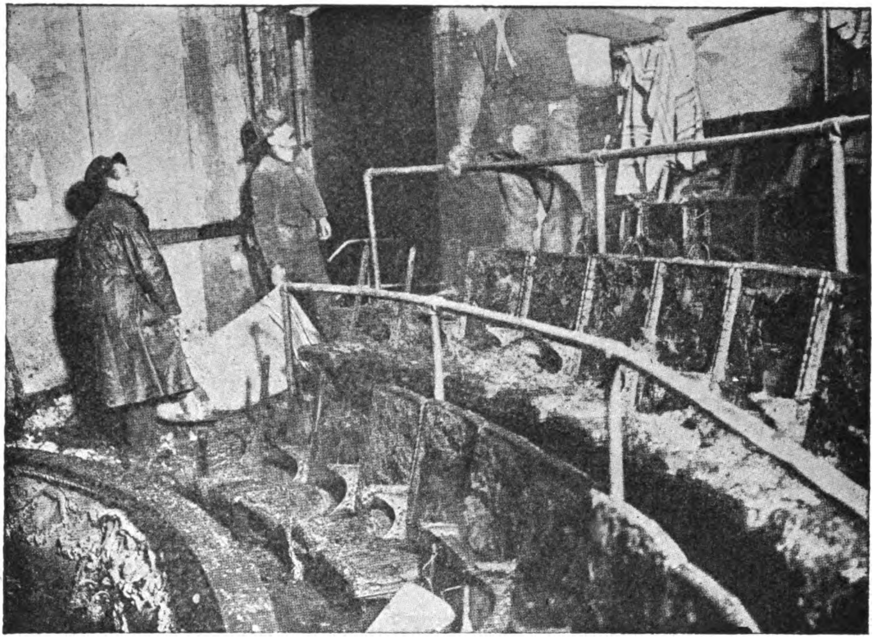


Fig. 58. After the Holocaust in the Terrible Iroquois Theater Fire, at Chicago, December 30, 1903

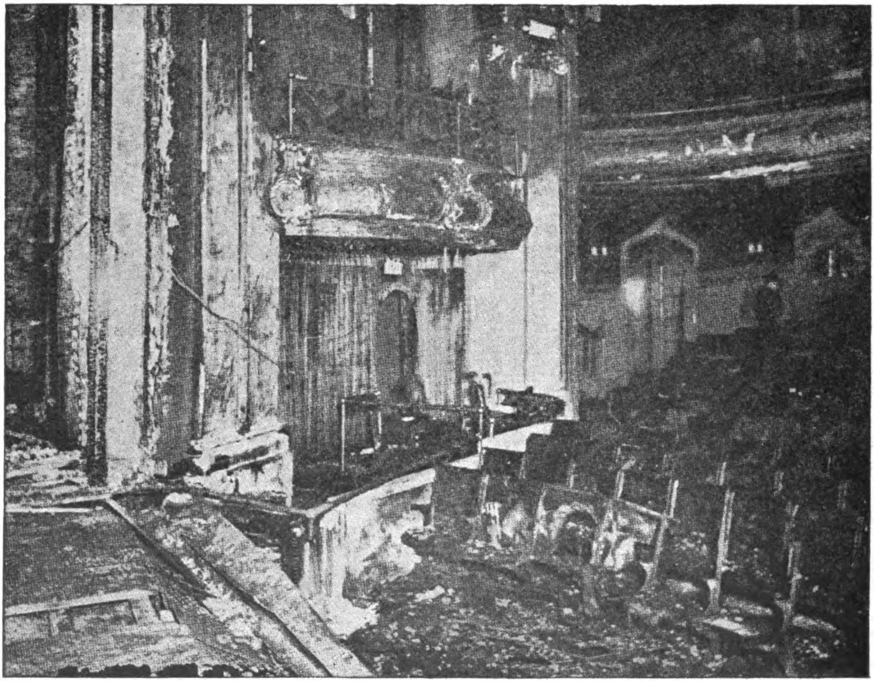


Fig. 59. The Iroquois Theater from the Stage

ferred, and of large size. If a fire gets beyond the control of the stage hands and special firemen, then it will burn the scenes and all such stuff and destroy everything upward and the smoke will pour out of the skylight; in this way the fire will spend itself upon the stage part and be warded off of the audience room. Here we have the direct opposite of the store or office building, but we must look upon the stage as one unit and must deem it necessary to make all of its structure fire-resisting and that which is not, had better be destroyed as fast as possible if we cannot smother the fire in its infancy. No building needs greater watchfulness than the theater. The auditorium is to be considered as another single unit, but there is nothing about it one cannot cope with successfully if he but follow the general principles laid down.

Church. A church is one large unit but easily handled; make it incombustible internally and fireproof externally. There are no goods stored in it or any possibility of internal fire if the structure itself will not burn.

Assembly Halls. In all theaters, churches, halls, and such places of public assemblages, there must be ample provision for the rapid exit of the people, for in the best fireproof building, someone may inadvertently or involuntarily start a panic. Even though there be no fire but merely a false alarm, terrible things may happen in a trampling, unordered mob. Therefore, provide plenty of stairs, or better still, inclined planes, from every gallery, and if they lead outside so much the better. The proportion of door-openings, aisles and all such details will be found in the regular text of "Construction of Buildings" and are also specially laid down in the building laws of all first-class cities. Under no circumstances should any such large hall, theater, or church be more than one story above the street. If it can be built right on the street level with no steps at all, so much the better.

Hotels. Hotels have to be most carefully studied; new problems arise in every building planned. But a careful analysis of what is specifically required in each case and an "application of *common sense*" will produce sane solutions for every problem. Remember, though, that if the provision of large means of escape is necessary in the theaters and halls and churches, how much more necessary are they in hotels and apartments where people spend much time asleep. The greater number of hotel fires occur between 10 P. M. and 6 A. M. Nothing should ever induce one to leave any opening from one story to another, and easy stairs and elevators should be provided in what might be called "extravagant" numbers. The stairs must not be in one place between two stories and somewhere else between the next two stories, but continuous, *a handrail which one can take hold of and follow down from the attic to the street.*

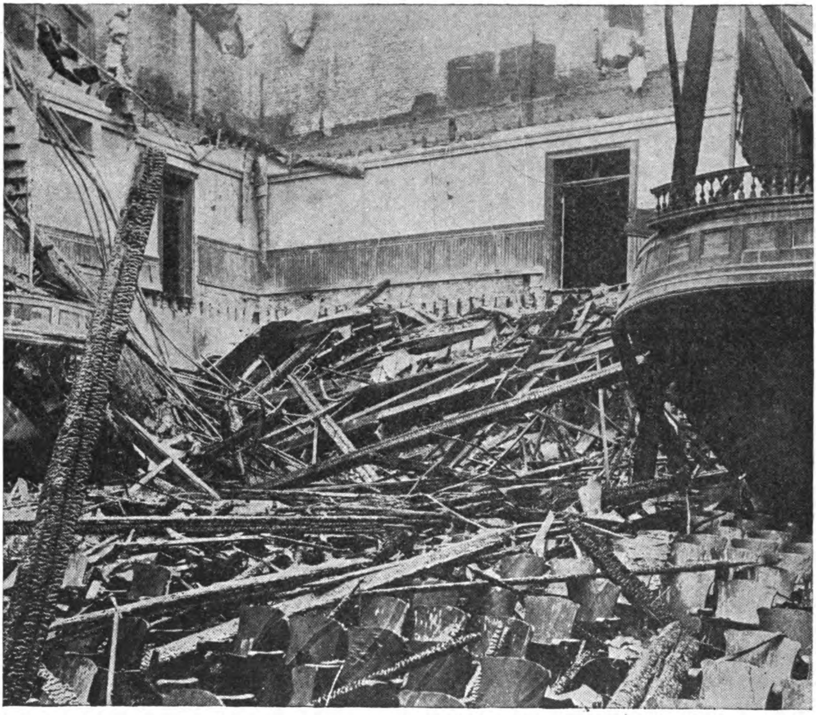


Fig. 60. A Theater Fire, Fortunately, when Unoccupied—Wooden Construction

No detail is too insignificant to deserve study and attention. For instance, it is deemed a simple enough matter to place a tank upon a roof, a supply of water for house and sprinkler purposes. To make such a tank's supports iron instead of wood is also sensible and a most commendable thing to do. But more is needed. If those iron supports are not protected from rust, painted from time to time, they will give way and down will come the tank. That was the cause of a recent and grave disaster at Montreal. Tanks improperly built, improperly supported, and otherwise thoughtlessly installed have, in just ten years' time, done fatal damage, destroying one or many lives and being the cause also of most serious conflagrations, in forty-five instances. Yet, not one out of a hundred thousand people, people interested in building, too, ever give more than a passing thought to the proper construction and support of the tank.

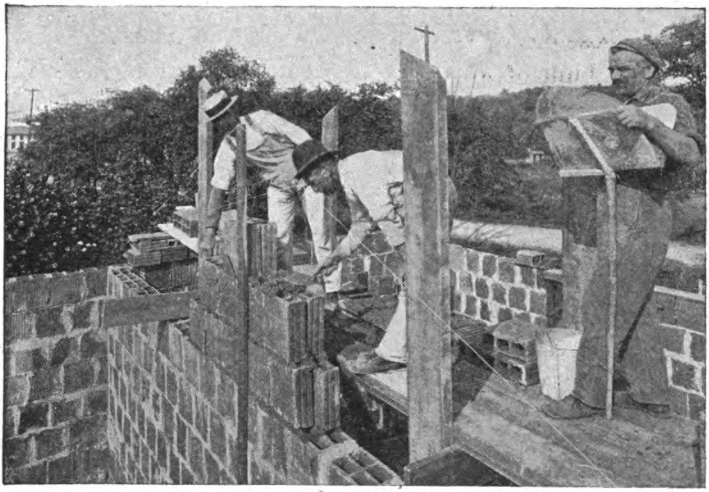


Fig. 61. Building Hollow Tile Walls
The blocks are laid up the same as in ordinary brickwork.

Fireproof Homes. Of all classes of buildings, houses contribute by far the greatest number to fire.

> Every wise woman buildeth her house . . .
> a wide house and large chambers, and
> cutteth out windows; and it is ceiled
> with cedar and painted with vermilion. . . .

You see that even in the time of Jeremiah the women wanted big rooms and many windows and, undoubtedly, innumerable closets, cubbyholes, and cosy corners—probably more than some of their good husbands could well pay for. In a great many respects the women of those days differed not from those of our own time. In building a house today the average woman wants just about three times as many rooms as she can possibly get for the money which the family has set aside to build the home; however, I will have no quarrel with her as to the number of rooms she wants and thinks she ought to have, where the flagpole ought to be, the particular location of the kitchen sink, or, for that matter, even the painting of her house "with vermilion," but I am going to scold about the "ceiling of that house with cedar."

The Hebrews of old built almost exclusively of wood; even Solomon built his magnificent temple of cedar and costly timbers, and as a result we have absolutely nothing in the way of historical remains of those days. Our fathers, at least those who dwelt in this country, also built of wood, for the same reason that the Hebrews

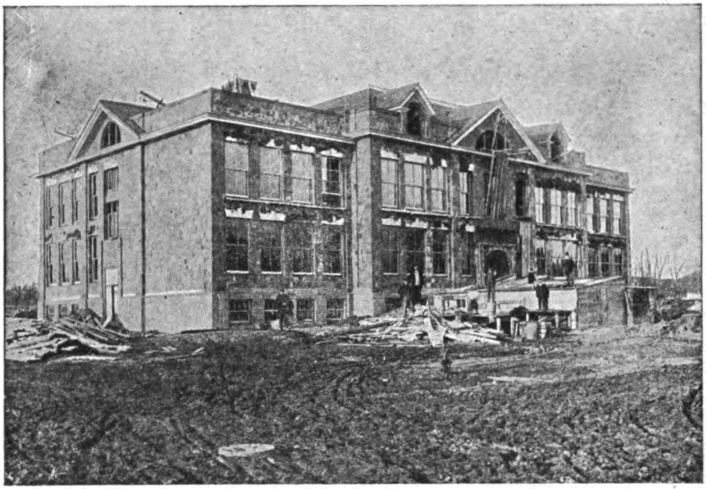


Fig. 62. The Rough Tile Work of a Fireproof School Building

did—it was the most available material—and we have clung to that habit as we cling to many habits, without rhyme or reason. True, clapboarding and shingles may be very artistically combined, and there are indeed some very tasty frame homes wherever we may turn our eyes. But none of these homes so built are *safe*. In the hearts of large cities, and within certain zones outside of those hearts even, such homes are not permitted, because of the dangerous character of their construction. In the suburbs they are exposed to the dangers of fire from within and innumerable dangers from adjacent fires, though the fire departments in most cities are so well organized that total loss is far less frequent than formerly. When once a house so constructed catches fire there is small hope for it, for few country places have any semblance of fire protection, and the result is total loss. Something like 80,000 houses burned down last year in this country. True, 42,000 of those were insured and the people got some balm with which to soothe their lacerated purses, but remember that for every dollar a community gets from the insurance companies it has paid in to those companies three dollars in premiums.

Men are learning by hard experience the folly of flimsy building. It is one of the national crimes. Apart from the Chinese and Japanese few people on earth have built as poorly as we did some years ago—and many of us still do it when we are not deterred by the law. Business men have come to realize the tremendous loss of property that is chargeable to inferior construction and the result is a general demand for better buildings, more fireproof construction. Some cities have advanced far enough along the lines of progress so that they will not permit any but fireproof construction within rather wide limits.

But our women still insist on having wooden houses, with their more or less elaborate wood trimming inside, wooden porches outside, shingle roofs, "ceiled with cedar" in the fullest sense of the word and made just about as inflammable as it is possible for an ingenious architect to devise—and our houses, therefore, contribute very largely to the annual ash heap. I am not contending for merely the elimination of wood in the exterior finish and construction of houses. Many people believe that the moment they have their outside walls of brick or stone, and the roof of slate or tile, their homes are fireproof. The floor joists, the partitions, all the interior framing and finish are of wood and become as dry as tinder in the course of a few years. The spaces between the rafters, floor joists, and partition studdings, are just so many flues. No sooner is there a little fire in the cellar or kitchen or some out-of-the-way corner than —pst! there it is in the roof and all over the house. Lives are endangered and much that the good housewife holds dear is destroyed, though the house itself may possibly be repaired. On that account do I aim my bolt at everything that is wood or inflammable or destructible by fire in a house.

The exterior walls should be of brick, terra cotta, or concrete—stone may be used under ordinary circumstances—while the floors and partitions and roofs—all the construction, in fact—should be of absolutely non-inflammable materials. And all this protection costs but very little more than the flimsy construction. Conditions, of course, differ in the various parts of the country, but as a general average I may say that a thoroughly fireproof house will not cost (in its initial expenditure) more than 7 per cent over the cost of the usual wooden structure with wooden joists, stud partitions, and lath. Taking into consideration the fewer repairs required to keep such a house in condition, its far longer life, the lessened insurance—if, indeed, any be carried—ultimate investment in a fireproof house is not nearly as much, anywhere in the country, as that in an ordinary structure. Many times, in fact, the initial cost of the better mode is even no greater than that of the poor one. A number of fireproof houses have just been completed in Pittsburg. They have cost, ready for occupancy, $4,500 each, and that includes some few little extras that have been thought of as the building went on. The lowest bids on those houses for wood construction were $4,000 and $4,125.

Why! anyone can figure it up for himself. In the ordinary city house the wide span floors, for instance, have 12-inch joists; between those joists there is laid 12 inches of cinder concrete, or other noise deafening material, in the endeavor to lessen the noises from overhead; there is a rough flooring on top, with a finished narrow-strip maple flooring covering that, and plastering on the under side forming the ceiling of the story below. Now, such a floor and ceiling in the completed stage cost here in Washington 40 cents a square foot. There will be a variation of two or three cents in different localities. Eliminating the maple floor, taking out the deafening, and using a finished pine floor, as is done in the cheapest kind of dwellings, you have an expenditure of at least 28 cents a square foot. Partitions built of 2 by 4 wood stud, wood lathing both sides, and plastered both sides, will average 20 cents a square foot pretty much all over the country. So much for wood. In fireproof construction, tile and concrete spans finished with an asbestolithic or granolithic or other incombustible plastic flooring, the under side of the floor plastered and all finished in good shape—fireproof and vermin-proof—cost from 26 to 28 cents a square foot. You see that the general supposition that fireproof construction is exceedingly costly is erroneous.

I am not advocating anything startlingly new, nor a great reform

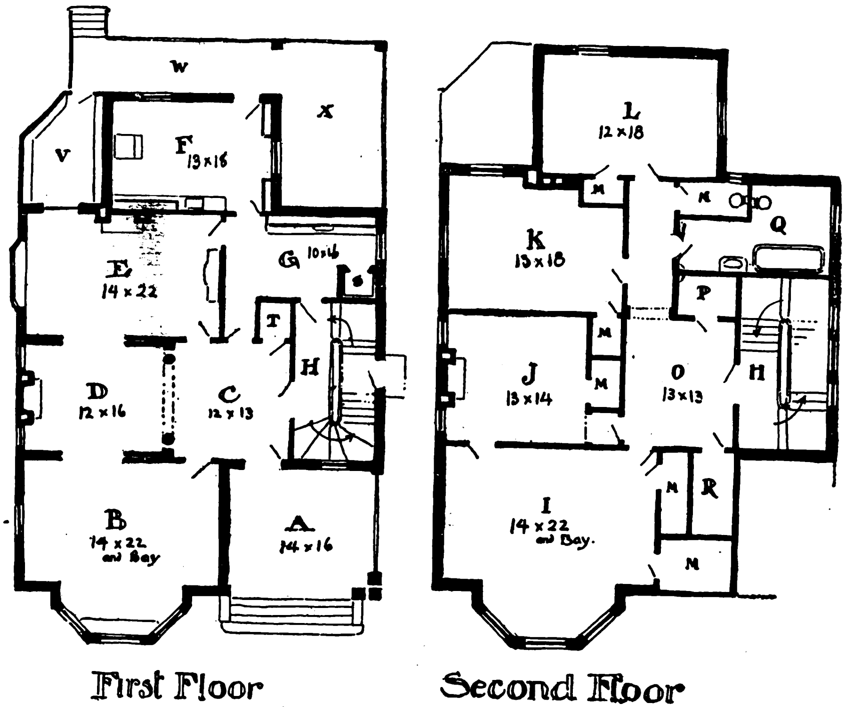


Fig. 63. Plans and Description for House A

HOUSE "A."

These sketches are the rough studies for the plans of a fireproof, $8,000 house in Portland, Ore. The size of the rooms is marked on each. "A" is the entrance porch—cement floor, concrete steps, etc. "D" and "C" are the reception hall and library, or living room. "B" is the parlor and "E" the dining room. These rooms communicate by sliding doors, so that absolute privacy can be secured in each. "F" is the kitchen and "G" the pantry. "S" is a fixed icebox, enameled-brick lined, "T" a coat closet, "V" a little conservatory off the dining room, "W" a back open porch and "X" a lattice-enclosed porch. People will keep baby carriages, lawn mowers, etc., on a porch, so might as well give them a place to do it properly. "H" is the stairway. It is an iron stair, enclosed in tile partition with self-closing doors, and the sash in the doors, giving light into the hall, "C," is filled with wired glass. These people are sensible and are willing to forego the delights of a draughty, dirt-communicating and dangerous in case of fire, but elaborate, open, ornamental stairway. Thus closed off there is not the slightest possible danger of fire communicating from story to story. This stairway serves all purposes. There is access to it from the pantry; it also goes on down into the basement. There is a landing at the ground level, so that the boys may come in that way and go up to their rooms without tracking dirt all through the house. The second floor shows bedrooms at "I, J, K, L," with closets at "M" linen and trunk closets at "T" and "R," bathroom at "Q" with separate closet—a great convenience—at "N." In the third floor or attic there are two rooms for boys, a trunk and storage room and servants' quarters, and in the basement there is a laundry, a furnace room, coalbins and a workshop.

in building material, nor anything of that sort; but am simply urging the adoption of as sensible a mode of construction in our houses as we have gotten into the way of using in our larger buildings. Building fireproof houses has become as necessary as the building of fireproof stores, hotels, apartment-houses and other places of a similar nature. It is not sensible to keep on building with old flimsy methods exposing life and property to the dangers that we know are ever present, as we have done in the past from motives of alleged economy, that have in reality proven to be the rankest extravagance. All that I am advocating is that the ladies forego the little pleasure they may derive from their dainty minarets of shingle, scroll-saw ornaments, beautiful green stained shingle sides to their houses and the endless wood—wood—wood trimming and finishing that is simply pretty because we have grown used to it, and allow the substitution in place of all this highly combustible material, of other materials that will not burn and that are not damaged if an incipient fire does occur in the house furnishings, carpets, etc. Brick, tile, and concrete are the materials that fulfil that requirement, and if they are used almost exclusively in the structural parts of a house, slate, stone, and metal, that are damageable by fire, may be used with more or less generosity in decorative ways because the possibility of their being damaged is virtually eliminated by the use of brick and tile construction.

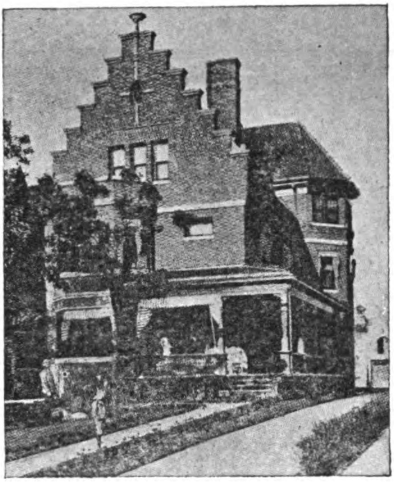


Fig. 64. Exterior Design for House, by Chicago Architects, That Would Fit Plans of House A

Do not imagine for a moment that the fire-resisting materials are the unyielding things that you have perhaps heretofore thought them to be, believing that a wooden house was the only one that could be made "pretty". The substantial homes are by their very nature far more beautiful and in the hands of a skilled designer become the most plastic and responsible medium for the very highest expression of our art.

Fireproof House Plans. Here is an illustration of a fireproof house plan; call it "A." This house "A" is to cost not one penny over $8,000. The sizes of the rooms are indicated on the sketches. It will be absolutely fireproof in that not one inch of wood will enter into the construction, but even in such a house there is the possibility of quite a fire. There is always a mass of furniture, draperies, and carpets, and until such things are made of steel and woven of asbestos, incipient fires at least are possible, and very probable, where servants are negligent in handling fire and where the ubiquitous small boy loves to play with the matches. The great danger with an incipient fire in a room is that it will spread and particularly upward if it is in the lower stories. In a great cotton warehouse, for instance, all on one floor, it will take hours and hours for that cotton to be consumed, while the same amount of cotton placed in a five- or six-story warehouse with stairways and elevators opening in on every floor will be totally consumed in as many minutes as it will take hours in the other case. The main tendency of fire is, of course, upward, and the most potent agent in its spread in a house is the omnipresent, openwork stairway. So that even in this fireproof house I enclose the stairway in a fireproof partition, and the windows opening from that stairway hall "H" into the other parts of the house are of metal sash and wire glass and the doors opening from the other rooms are automatically self-closing, fireproof doors. The thing is that a person going up or down stairs has to open a door. It may be deemed a slight inconvenience, but some day that very act may mean the saving of your children's or your own lives. Even if you still persist in building of wood, you should close off your stairways so that every floor may be a separate entity and the stairway not a means of immediate communication of fire from below. Apart from the fire question, did you ever stop to think that the open stairway, while perhaps rather attractive esthetically, adds just about 15 per cent to your cares, work, and inconvenience? Every

Fig. 65. Exterior Design for House, by Chicago Architects, That Would Fit Plans of House A

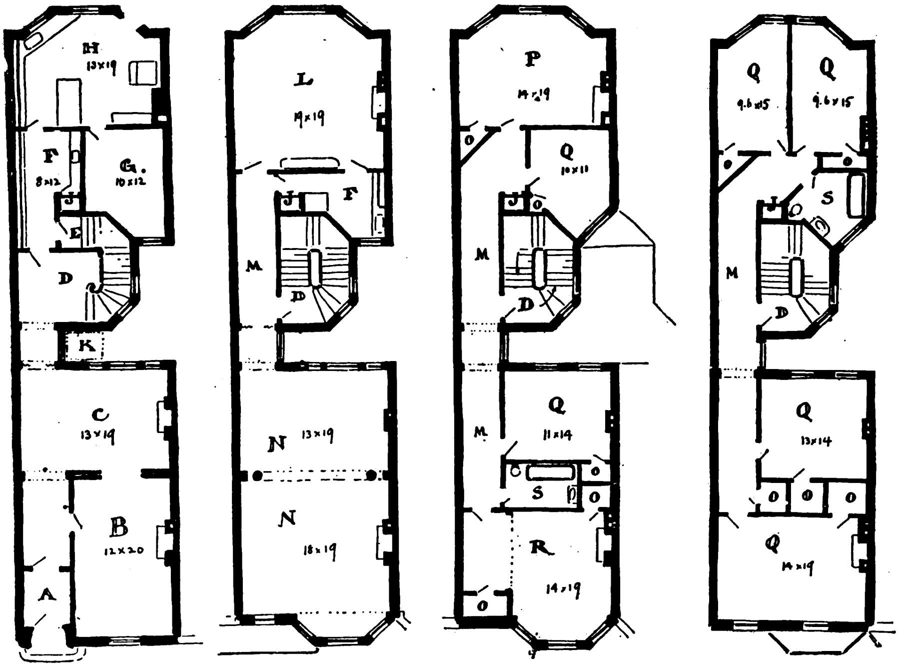


Fig. 66. Plans and Description of House C

HOUSE "C."

Is one of a row of eight houses for Philadelphia. They are 20x75 feet. They will cost about $7,500 each, will be rather nicely finished, absolutely fireproof in construction and will rent for about $70 a month. One enters at two steps above the street into vestibule "A." To the right there is the man's library or smoking room. At "C" is the reception hall, "D" is the stairway, "H" the kitchen, "F" the pantry and "G" servant's room. The lot falls away to the rear, so that there is a sub-basement, accessible by stairway "E" and in which will be the heating plant, laundry, servant's bath, coal, etc. The second floor has double parlors, "N N," on the front, dining room at "L," serving room at "F." The dumb-waiter, "J," serves all the stories in the house, carrying meals in case of sickness to the upper stories and convenient for other household purposes. The partitions around it are fireproof, and it is closed with an automatically self-closing door at every story, so that there is no danger of fire communication by that means. The stairs at "D" are well lighted, but enclosed in a room by themselves and with a self-enclosing door, and offer no means of communication of fire from story to story. Note how they are placed so as to serve all the purposes of the house; no need of back stairs. Note also that at "K" are guides on the walls and a platform elevator, geared to a block and tackle on the roof and worked by hand-power. In the hallway on the first floor and all the other stories by this freight elevator is a window opening, full size, a French sash, and the idea is that in moving furniture or other heavy things there is no lugging up and down the stairs. A piano or other bulky piece is carried along the level from the front door, put onto this platform elevator and hoisted up to the story desired and there carried out on the level without much ado. The third floor has bedrooms at "P, Q" and "R," with closets at "O," "O" and bathroom at "S." "P" or "R" may be used as sitting room or sewing room, or nursery, for that matter. The fourth floor has four bedrooms "Q, Q, Q, Q," closets at "O" and a bath at "S." The stairs go on up to an attic that can be used for storage purposes. The space for the freight elevator hoist "K" is so arranged that some time the the owner will install an electric passenger elevator. Building a wall at the back will be all the change necessary in construction.

time you sweep a room in the upper stories you are merely transferring dirt to your lower stories. The stairway means a draught all winter, the addition of about 12 per cent to your coal bill, and oftentimes the addition of a very large percent to your doctor's bills. Besides, with the open stairway it is impossible to shut off the upper floor when you have company below. Altogether, I consider the open-stairway feature one of the worst in our modern house construction — a menace to life, health, comfort, and peace of mind. This house "A" is merely typical, a thousand modifications of the plans are possible, and, indeed, any plan of a house may be easily modified so that the materials used may be non-combustible, the means of communication of fire may be eliminated, and your house may become a fireproof one.

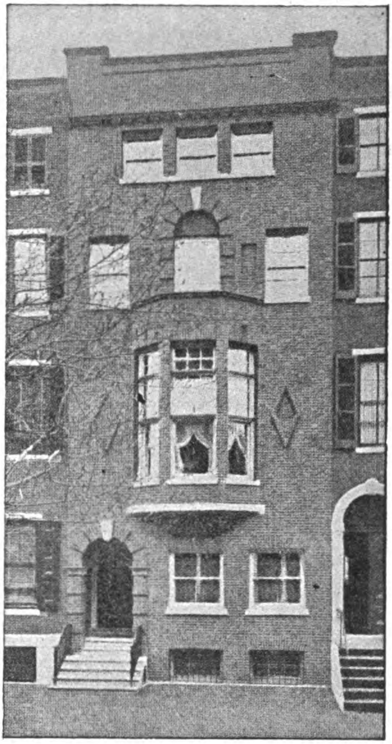


Fig. 67. A Suitable Exterior for House C

In the crowded resident portions of cities, fireproofed houses are even more necessary than in the suburbs. Sketches of the floor plan of house "C" are studies made of a row of eight houses in Philadelphia. The construction will be absolutely fireproof, the stairs enclosed, well lighted, and furnished with automatic doors in fireproof partitions between stairs and halls. Usually, with front and back stairs, a little over one-fifth of the available floor space is thrown to stair room. By a rather ingenious arrangement it will be observed that in this house, as in house "A," the one stairway is made to serve all purposes and can be made so, not only conveniently, but with absolute satisfaction, eliminating the necessity for servants passing through living rooms to get to the stairway, as is unavoidable ordinarily where but the one stairway is used. All the windows in the

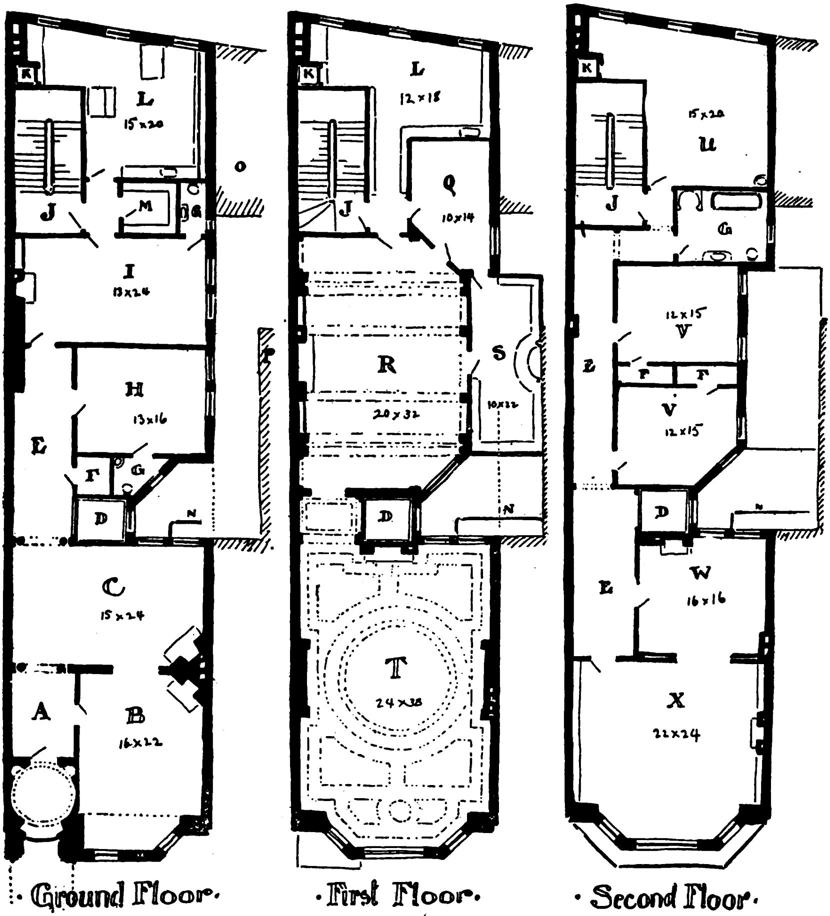


Fig. 68. Plans and Description of House B

Entirely covers a lot 25 feet front, 100 feet deep, backing on an alley. Some light is obtained in the upper stories on the left of the plan by having windows in the party wall above the adjoining residence, while on the right there is a very fine residence shown on the ground-floor plan at "P," with an automobile house in the rear at "O." The arrangement of this adjacent house is such as to permit of very good lighting of this new residence on that side, and arrangements have been made with the owner so that the conservatory on the first floor at "S" overlaps the lot and is attached to the other man's wall where there are no windows. The ground-floor plan shows the entrance at "A," Mr. H.'s library and office at "B," reception room at "C," hallway at "E," coat closet at "F," passenger elevator at "D," kitchen at "L," dumb-waiter at "K" and closed stair at "J," wine room at "M" and a room at "I" that is used ordinarily for the servants' dining room, but on extraordinary occasions as a gentlemen's dressing room, while room "H" is used ordinarily for Mr. H.'s stenographers, and, in extraordinary cases, as a ladies' coat and dressing room. "G G" are toilet rooms off of these rooms. First-floor plan shows the grand drawing room at "T" and the dining room at "R," conservatory at "S," serving room at "L" and breakfast room at "Q." Elevator at "D" and stairway at "J." Some indication of the ceiling treatment is shown on plan. Second floor shows family sitting room lined with bookshelves at "X," Mrs. H.'s sewing and writing room

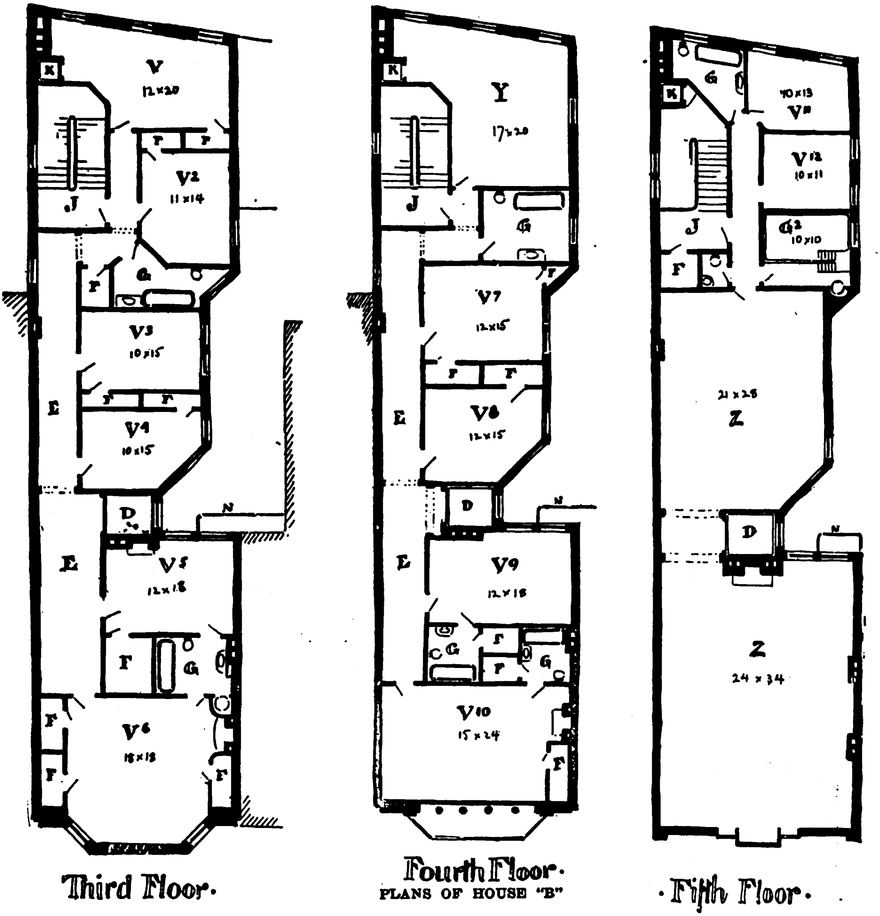


Fig. 69. Plans and Description of House B

at "W," day nursery at "U," with the two young gentlemen's rooms at "V V" and bathroom at "G," with shower, etc. Third-floor plan shows Mrs. H.'s bedroom at "V-6," Mr. H.'s at "V-5," with private bathroom at "G," shower, etc., nursery room for baby twin boys at "V," nurses' room at "V-2" and rooms for two little girls at "V-3-4," closets at "F," bathrooms at "G," elevator "D," dumb-waiter "K" and stairs at "J." Fourth floor shows the young lady's room at "V-10," with private bathroom "G," guest chambers at "V-7-8-9," billiard room at "Y." Fifth-floor plan shows housekeeper's and butler's rooms at "V-11-12," bathroom at "G." "Z-Z" ordinarily gymnasium, but also used as ballroom. "G-2" is a plunge and shower bath. The stairs, dumb-waiter and passenger elevator are not only enclosed in fireproof partitions, but also have automatically self-closing doors, so that there is no possibility of fire communicating from story to story. Plus all this, Mr. H., who has been burned out three times in his life, has a fire escape at "N." All the windows at the sides and back of the house are of metal sash with wire glass, and apart from the furniture in the house there is absolutely nothing in the construction that is combustible. The exterior shows a very plain, but rather impressive front, not overornamented, and a house that carries the idea of solid dignity and repose rather than any ostentatious display of wealth.

light courts that, as will be observed on the third-floor plan, are large and sightly, are of metal sash and wire glass, and every precaution is taken to avoid possible fire damage from within or from without. The dumb-waiter is arranged with automatic doors, as are all other openings through the floors. Any one of the three exteriors shown would fit such a plan.

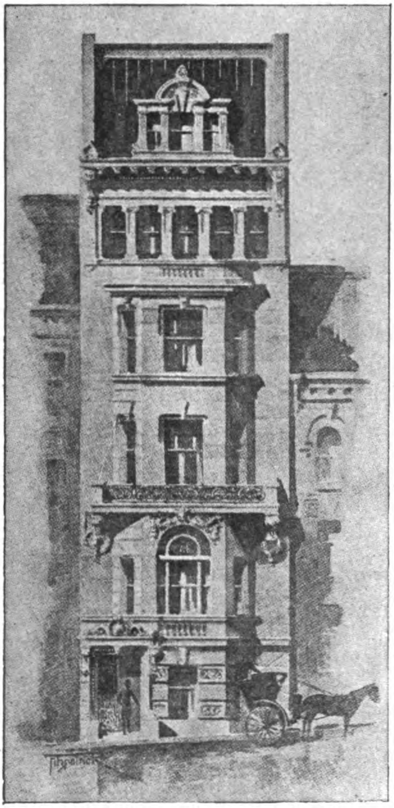


Fig. 70. Exterior of House B

House "B" is of a class that many may be interested in, but that, unfortunately, few are able to build. It is the residence (for the winter months) of Mr. H., a wealthy man, who spends only a few months at the height of the season in Washington, and who intends this house not only as a home during these periods, but as a place of very sumptuous entertaining. He has been burned out of house and home three times in his life, so that he was an easy convert to fireproof construction. More than that, he has given the subject some study, under proper direction, and has become an enthusiast on the subject. The sketches for the plans and exterior are but the first rough studies and are, therefore, susceptible to some, though not many, modifications. I believe I am safe in saying that the house, when completed next year, will be the nearest absolutely fireproof residence that has yet been constructed in the country. Not only are the constructive features to be fireproof, but the finished floors are to be of asbestolithic cement, marble mosaic, and other such materials; the window sashes are all to be of metal with the glass on the sides and the rear of the house wired, and the door casings, etc., will be moulded and ornamented in Keene's cement, with the doors themselves of pressed metal. There will not be $50 worth of woodwork in this entire house which I estimate will cost somewhere about $60,000, exclusive of certain luxuries demanded by the owner. The exterior of the house, as will be noticed, is almost severely plain, a feature which is in much better taste than the usual over-ornamentation. Many special features of interest will be noted

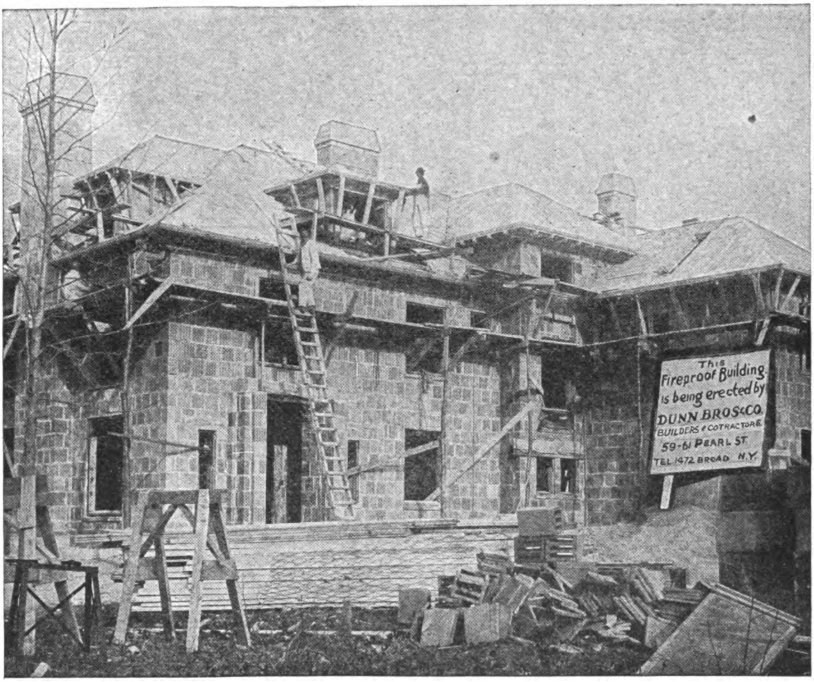


Fig. 71. A Tile Fireproof House, Roof, Walls, Floors and All of Hollow Tile

in the general arrangement of this house. Some may wonder at the absence of grand monumental stairways. That is a detail which is absolutely eliminated. There is a passenger elevator, arranged in fireproof partitions and with automatic fire doors, that serves every floor. It will be electrically operated so as to stop at any desired floor by merely touching the electric button, and the doors cannot be opened by anyone while it is in operation. There is not half as much danger of accident in such an elevator as there is in a stairway. At the rear of the house there is a very handsome, fireproof staircase for general purposes and to be used in case of accident to the elevator, which is somewhat remote, as connections are made with two powers.

Incidentally, I contend that anyone building a house, a city house, of more than three stories, costing over $10,000, is not forgivable if he or she does not install an elevator instead of a stairway. Electric elevators are now being made with simple machinery, take little space, are absolutely safe, are easy of operation, and cost but comparatively little for installation. The house elevator is a thing that is near at hand and ten years from now elevators, even in houses of two stories, will be as common as electric street cars are today.

Houses are now being built of tile stuccoed externally, a simple inexpensive construction and one doing away altogether with a steel frame of any kind. And they are building houses of tile and concrete centering; of concrete in forms; of concrete sections made in shops, and of concrete blocks. Beautiful houses can be designed in any one of these modes of construction, though I have not yet seen a concrete block house I would care to live in. Personally I prefer the tile house for lightness of material, temperature, resistance, soundproofness, dryness, and ease of construction.

How strange it is that a man should go to such trouble, expense, and employment of skill in order to have his shop or store or office building fireproof and yet be willing to live and have his family and probably his most valuable possessions, in almost any kind of a house, however much of a tinder box it may be. The *fireproof house* is as important as the fireproof bank or store or factory, if not more so, and the more people who live in that house, the more perfectly fireproof it should be. Therefore, the hospital, the hotel, the apartment, the asylum, and the college dormitory should be superlatively well built.

It has been stated that "slow-burning," "mill construction," "semi-fireproof," and all those half measures were unavailing and misnomers. Insofar as a conflagration is concerned it amounts to nothing, for those buildings disappear in almost as quick order as do the frankly fire-trap ones. But there is this one advantage, viz, that an internal fire is retarded enough so that escape is perhaps possible and, of course, the more fire-resisting the construction is, the better it is for the occupants. But half-way measures in any phase of life are so unsatisfactory. You spend almost as much for

Fig. 72. "Slow-Burning" or "Mill Construction" After a Hot Fire, Utter Wreck

"semi" fireproof construction as for the real thing and if fire does occur and gets pretty hot, your contents are destroyed and your building is damaged 60 to 90 per cent of its cost value—the loss might

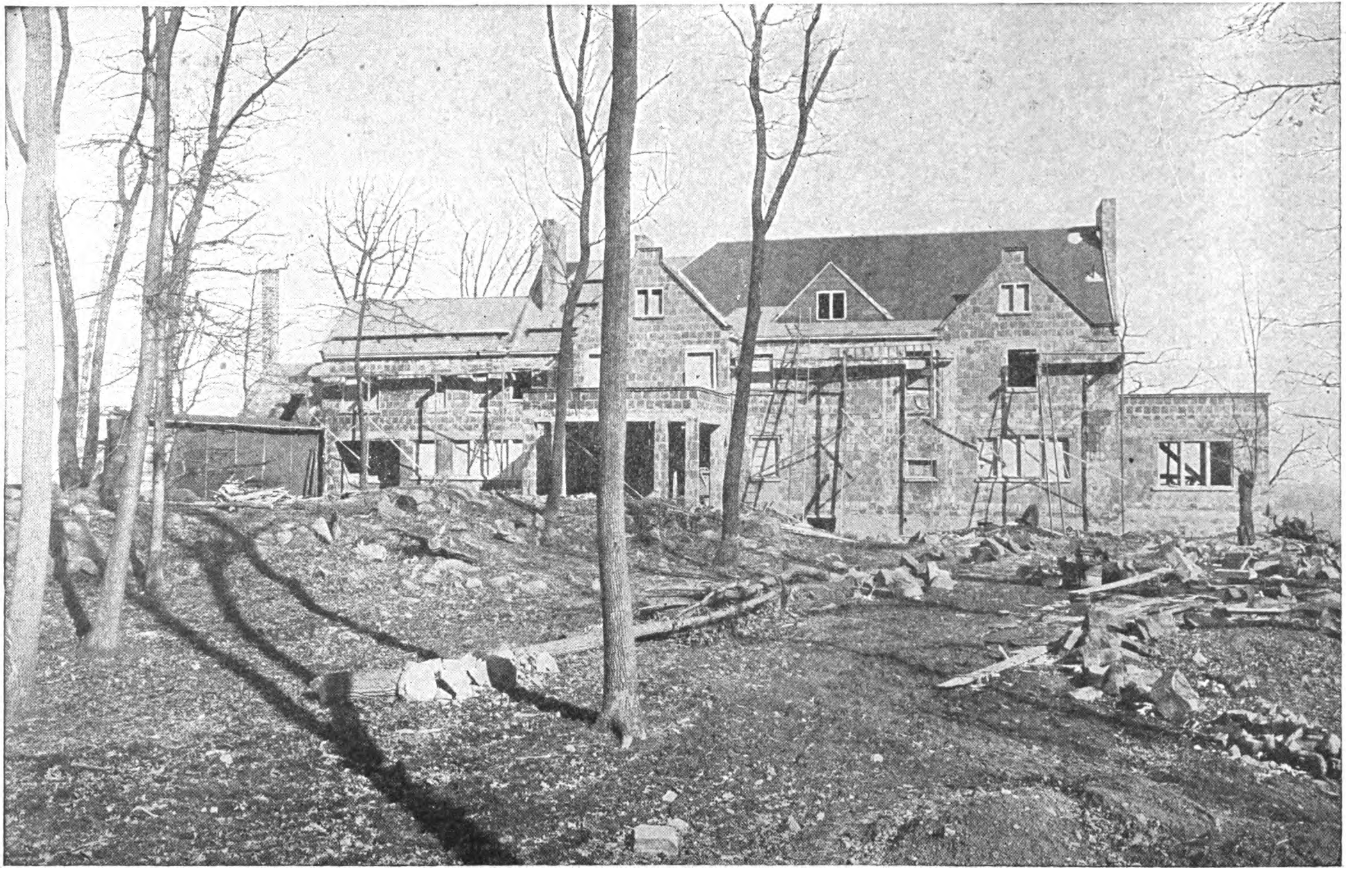


Fig. 73. The Unstuccoed Shell of a Fireproof House

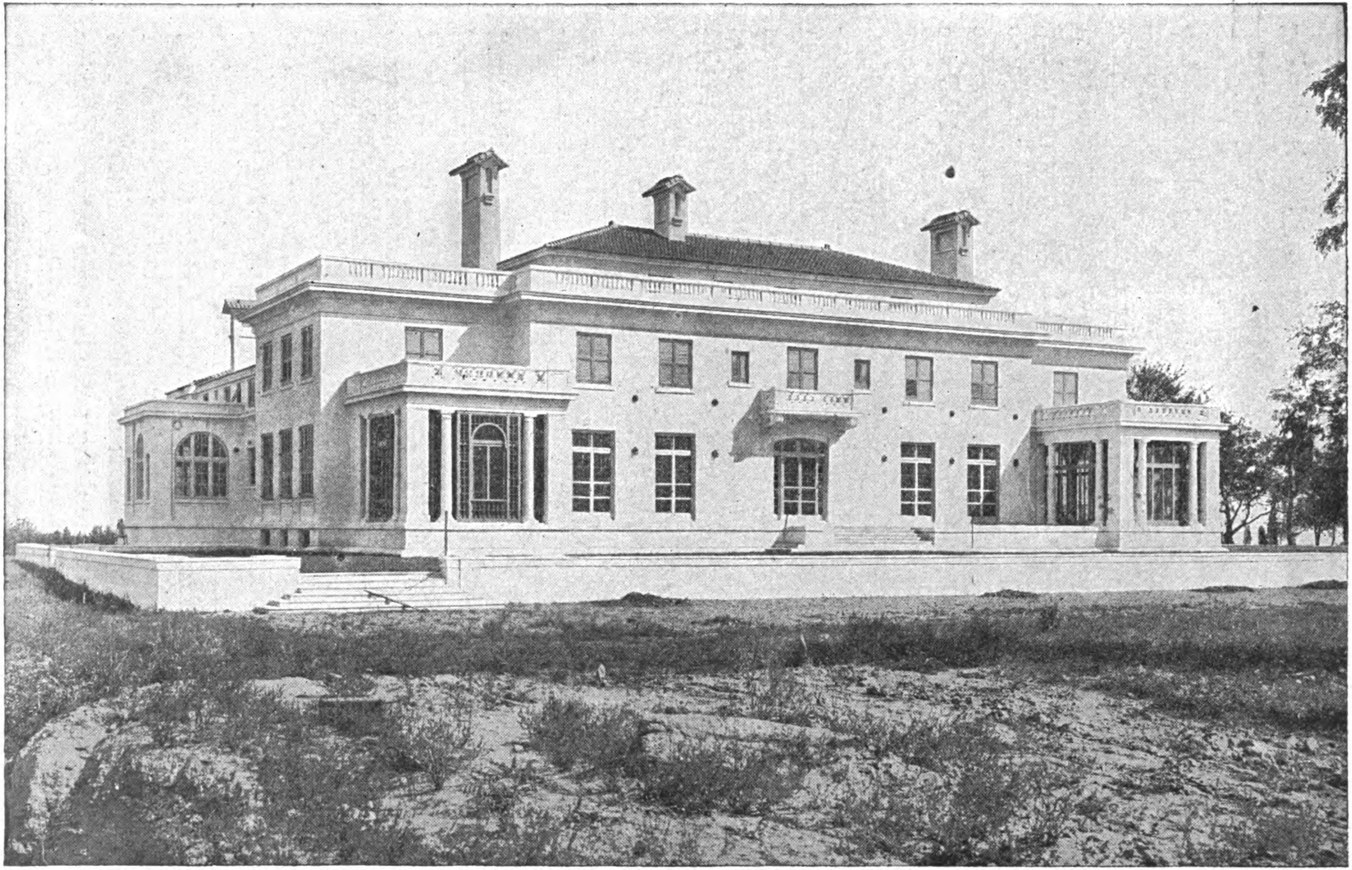


Fig. 74. A Long Island Fireproof House. The hollow tile covered with stucco

as well be total for you shall certainly tear down what is standing and do it over again properly if you are wise.

Although compromises are unsatisfactory, there may be circumstances where and when it is really impossible to build in a thoroughly fireproof manner. Suppose even that the usual frame house is the only thing possible, you can still, by the exercise of a little ingenuity, make it so that there is a chance of getting out in case of fire and of even retarding that fire so that it may be extinguished before it goes too far. Offer as little chance for ignition as possible in places where merely dropping a match means a sure fire —in fuzzy, woolly floor coverings for instance. Then cut off the structural air spaces and flues, that so readily and quickly convey fire all about the house. Between the joists set boards on edge, boards the exact size of that joist space instead of the usual cross-bridging, and lay a course of brick or concrete or asbestos at each floor line between all the studding timbers, so that the flue spaces between studding are only one-story high instead of being continuous from cellar to roof. All such carefully thought-out details will be mild retardants, but can hardly be called "fireproofing." If we accept the best lexicographic definition, a building to be *fireproof* must be *proof against fire.* Something that merely postpones the end, defers the destruction, is certainly not making a building invulnerable.

Building Code. From a fire prevention standpoint it is natural that in a model Building Code we should exact *absolutely* fireproof construction in all buildings. But, though enthusiasts, the Society of Building Commissioners do lay claim to the possession of some sense and we realize that such a requirement would simply scare into positive inaction every city in which we would suggest it. Discretion therefore prompts us to modify these exactions, to temper them so that there will be some hope of their being adopted. We have been careful to ask for nothing but what one or more cities already exact. No city cares to be a pioneer in any reform; its first question always is "What other cities are doing what you ask us to do?" and with this code we can truthfully say that six are doing nearly all that we have asked and twenty others are doing much that was suggested, having rebelled on some requirements only, and in each case different requirements, so that no one regulation has been unanimously rejected.

Here is an editorial from the "American Architect" of a recent date. It echoes the sentiment that now seems to obtain throughout the country:

A strong sentiment in favor of improved laws governing the erection and maintenance of buildings is manifested in widely distant localities. New building codes are being formulated in such cities as Rochester and Syracuse, N. Y., and in Portland, Ore., one has just been adopted. This document, patterned largely after that of Cleveland, Ohio, is interesting as showing people in older and more settled sections of the country what has been accomplished in the Northwest in the way of substantial development. The need for the strictest supervision over structural, fireproof, and sanitary arrangements is the surest sign of civic growth. The provision in the Portland code for two grades of fire limits—that is, areas in which the law will permit the erection of only fireproof and semi-fireproof structures respectively—is interesting and should be more widely applied in some of our large eastern cities, which will permit the erection of the flimsiest and most inflammable structures in the immediate proximity to the fireproof zone, thus affording a real passage to a conflagration sufficiently intense to force its way through openings in the walls.

A community that will lend its united support to a provision of this kind, carrying with it a large increase in the cost of buildings not of the first importance, deserves to be congratulated on its far-sightedness. If these large cities that have a very considerable population dwelling in the neighborhoods of business sections could be aroused to the true state of affairs, they too might be induced to pass similar protective restrictions. Every now and then a disastrous fire claims victims living in a section charted as extra-hazardous by the insurance companies. A restriction classifying the construction requirements according to environment, as well as according to a building's use, would operate to bring about naturally that classification of buildings so helpful for better conditions in our cities in every way. We hold this out as a suggestion to the commission that will take up the further revision of building codes, especially in the city of New York, where conditions are, perhaps, as unsatisfactory as in any large city.

In connection with the matter of a building code, it must also be remembered that as we have observed, the insurance companies exact such construction only as will best protect their interests in your building. There are a number of things upon which you may lose that do not concern them; it is *your* business. Their care of your interests for your sake is quite incidental and chiefly conspicuous by its absence. It is purely a business proposition. So with a building code. In it we are chiefly concerned in the community's welfare, its protection from conflagration, the prevention of spreading fire. The individual's interest goes way beyond that. For instance, we prescribe just how a wall should be built so as to keep it from falling down and hurting people and to stand as a secure barrier against fire's exit or entry. But we are not concerned as to how that wall shall be plastered and decorated. The code may direct the minimum excellence of such work, but it is a trivial detail, one that will neither

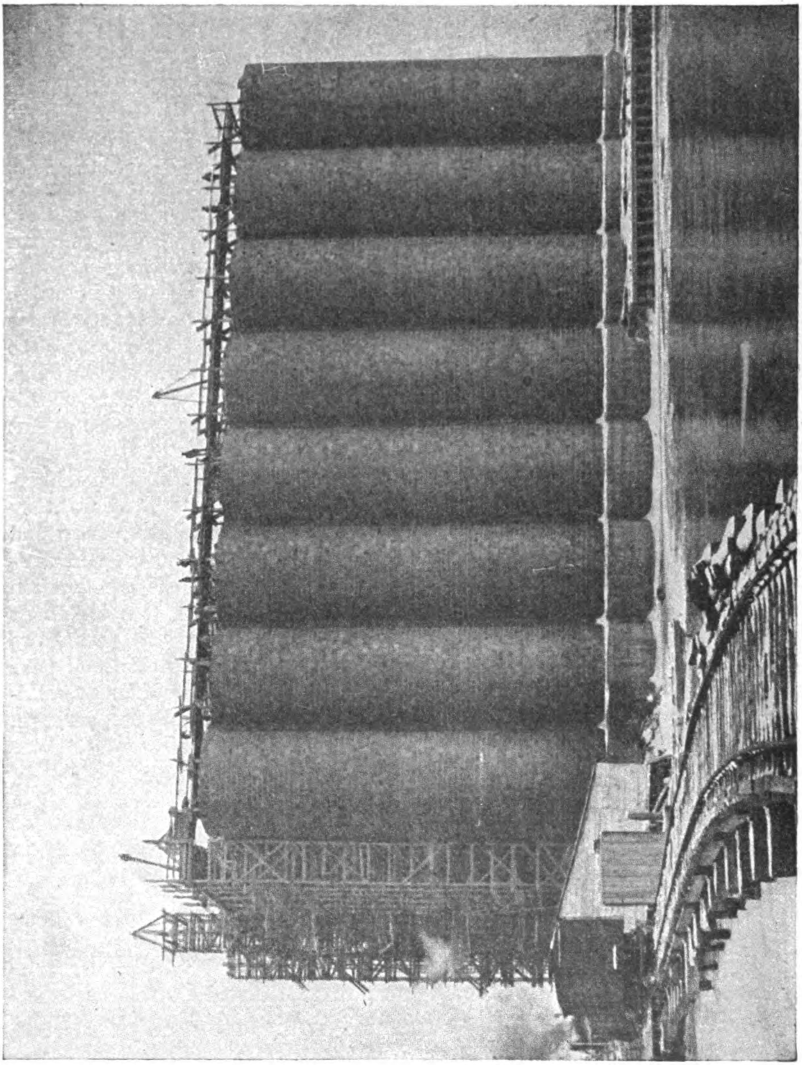


Fig. 75. Tile-Grain Elevator Bins
The most modern and approved elevator construction

keep the wall up or make it much more fire-resisting. The decoration may burn off and the community will not suffer the loss; that is *your* loss, *your* affair.

Now then, how very unwise it is to build only as well in all details as the city compels or as the insurance companies exact. Neither is particularly interested in your business or the especial safety of your property save as a very small unit of a big whole. These requirements should be considered as the very minimum of excellence, your own interest should dictate and your sense appreciate that a building should be better in all its details than is absolutely demanded.

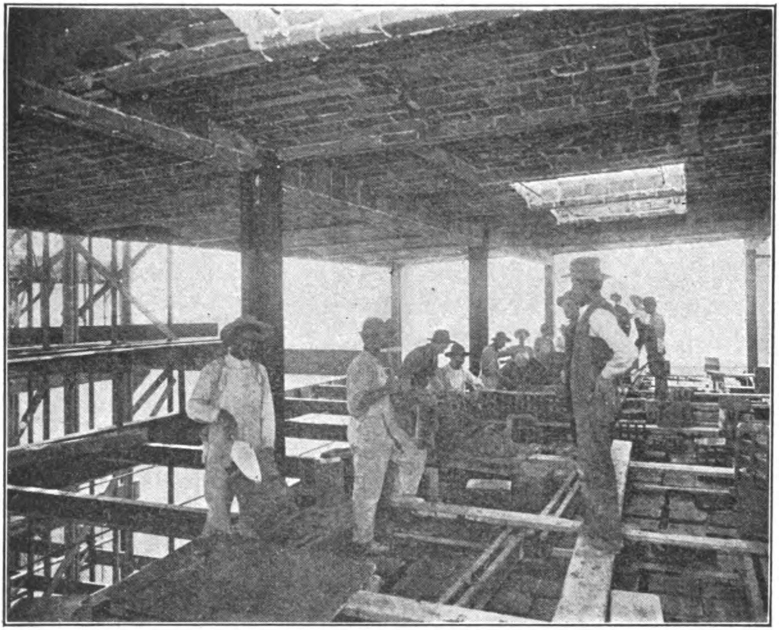


Fig. 76. Building the Floors of a Modern Skyscraper

In traveling only the railway fare is obligatory, the sleeping car, dining car, and other luxuries are optional and extra. But how much they contribute to your comfort and safety! Well, so with a building code. It exacts only that which is most essential and to not do more than it exacts, wherever this is possible, is like refraining from sleeping and eating while traveling because of some foolish notion that the flat railway fare is all that should be expended for travel.

Along with fireproof and fire-retarding construction must go carefulness and a sufficient water supply to assure one that nothing like a hot fire can occur. Every building should be completely equipped with hose, the best extinguishers available, standpipes, individual tanks and pumps if there is any question about general supply and sprinkler systems. These individual tanks have to be carefully attended to, also. They must be properly supported upon continuous columns or other sufficient foundation and not planted down anywhere upon the roof. Time and again have wooden or other insufficient supports under such tanks given away and precipitated these great tanks through the roof and several stories, doing terrific damage and often causing disastrous fires and loss of life. Strange how the upsetting of a *water* tank could set fire to a building! But it is so in nearly every accident to a building—an earthquake, anything—fire is generally the *finale*. Buildings are so poorly built and so inflammable that any disarrangement disturbs a flue, or places wood near a light or something or other that can only result in—fire. Begin the trouble anyway and it is more than apt to terminate in smoke! The more precautions taken the greater the safety. Watchmen and automatic alarms help in that direction. And the training of one's employes or family in fire drills is but sensible, drills not only in getting out of a building but in doing the right thing at the right time to choke a fire in its incipiency, or to fight it successfully if it has gathered headway. Children and teachers in schools, nurses and employes in hospitals, clerks and janitors in stores, every one should have his appointed place and work in case of fire and be drilled so often and well that when the emergency arrives he will do what he ought to do quite as a matter of habit. It is the compulsory drills on board ship and the constant watchfulness that make ship-fires so comparatively few.

STANDARD TESTS OF BUILDING MATERIALS

One of the last appropriations made by Congress in 1910 was a liberal sum with which the National Bureau of Standards might begin a series of comprehensive and exhaustive tests of building materials. It was a timely appropriation and the Bureau selected to do the work is the logical one for that purpose, the idea being to standardize weights, measures, materials; in fine, to create standard *American standards*. Heretofore there has been some work done by the government in the way of testing for fire resistance, strength, etc., the materials used in government construction, but it has been more or less haphazard and scattered; as it had been done by a dozen different divisions, it lacked direction and unity of purpose, and consequently was of comparatively little value. The Bureau of Standards, under the splendid direction of Dr. S. W Stratton (formerly of the University of Chicago), with the perfected equipment he has given it and the enthusiastic and able corps of skilled chemists, physicists and engineers he has gathered about him, cannot fail to give us magnificent results, established facts, standards to work to in the way of fire-resistance in construction, that will be of inestimable value to the building interests and to the country generally.

The following paper by James E. Howard, engineer, physicist of that Bureau, describes one of the first series of heat tests of building materials made under the new order. It is interesting and germane to the subject we are considering:

The necessity for acquiring exact knowledge upon the action of heat on building materials as a basis for judging of the manner in which losses or injury may be averted, or the effects of such a destructive agency as heat minimized, will be taken as a matter quite evident to all. But to obtain this information there is involved a large amount of laboratory work as well as the collation of data through most careful observation of fires and their effects.

It is recognized that heat is capable of destroying the integrity of any and all structures, but that each of the materials of construction is capable of enduring in some degree exposure to high temperatures, and that a study of their physical properties under conditions which may be encountered is essentially the foundation on which intelligent efforts for the prevention of fire losses must rest.

The first manifestation which is noticed when a rise of temperature occurs is the expansion or increase in volume of the material. Simultaneously therewith the strength and certain other properties may undergo a modification, at first apparent only through critical examination, but eventually as higher temperatures are reached, the effects become menacing and finally destructive. Chemical as well as physical changes occur in some of the materials of construction.

Not only is a high temperature menacing but the rate of change is also detrimental to some classes of materials. Not so perhaps if the temperature of the entire mass changed rapidly, but with low conductivity and a friable nature, injury may result from internal strains. Furthermore the proper distribution of stresses in a structure may be so disturbed by reason of parts thereof being heated that cases of overloading may occur, even to the limit of failure.

In any change toward high temperature there is, in fact, a tendency in the direction of ultimate injury, although a moderate change is of no particular account. But what constitutes a moderate change is nevertheless different in one class of structures over another. Changes in temperature unnoticed in a building must be provided for in a bridge, therefore an unqualified statement on the subject is difficult to make.

A property of materials similar to that of expansion or contraction by changes in temperature is that of extension or compression by reason of changes in load. This rate of change, or in other words the modulus of elasticity, presents a wider range in values in different structural material than the coefficients of expansion by heat. So far as is known, however, these two values bear no relation in common to each other.

As temperatures increase the metal portions might at times be the first to undergo a change in strength and rigidity, assuming those portions were accessible to the flames. But again the rate of change may be the controlling factor, and it becomes necessary to assume that slow heating occurred, a condition not often realized in a conflagration.

Before the ultimate strength of any part of a structure is reached there may have been so decided a modification in the distribution of the loads by reason of the successive changes which have prevailed that the final appearance is not necessarily indexical of the primary cause of failure. So many reservations are necessary to tie in any general statement that further remarks of this kind will be suspended and a number of diagrams presented on which are shown features on the physical properties of structural materials which have a bearing upon the subject.

Fig. 77 shows the relative rigidity of structural materials. Steel has the highest modulus of elasticity of any of the materials used and its relative rigidity is indicated in the open space above the full line at the left-hand side of the diagram. The several open lines above each of the solid ones represent in turn the relative extensibility or compressibility of the materials named on the diagram, based upon their respective moduli of elasticity. These values pertain to the materials when stressed by comparatively low loads, or within their elastic limits.

Two values are given for cast iron, and two for each of several other kinds of material, while for brick three are shown, representing hard, light hard, and salmon brick. In the case of long leaf pine the difference usually found between the tops and the butts of the trees is indicated by the two open lines of the diagram.

The significance of the lines on the diagram is this: if each of the materials represented thereon were loaded by compression with the same load per square inch of sectional area, then their shortening in height would take place relatively as here indicated for columns originally all of the same height. That is, a load applied to a steel column of such a height that its total compression would amount to 1 inch, and such a column of steel need only be 80 to 90 feet high, then the same load applied to a cast-iron column would shorten it from $1\frac{5}{8}$ inch to 2 inches. To carry this comparison to the other materials a lower stress per square inch would need to be considered than contemplated in the case of steel and cast iron.

But on a suitable basis of comparison the load which would shorten a steel column a given amount would shorten a monolithic column of hard brick three times as much, and if made of salmon brick, sixty times as much. Neat Portland cement is seven and one-half times as compressible as steel;

sandstone from seven and one-half times to twenty-five times as compressible, and so on for the other materials as indicated on the diagram.

It must not be forgotten, however, that the results on the diagram refer to the compression of the materials within their elastic limits. It is quite a different matter when considering overloads which cause permanent sets.

Fig. 78 shows the curves of tensile strength of three grades of steel when at different temperatures. Over the range of atmospheric temperatures

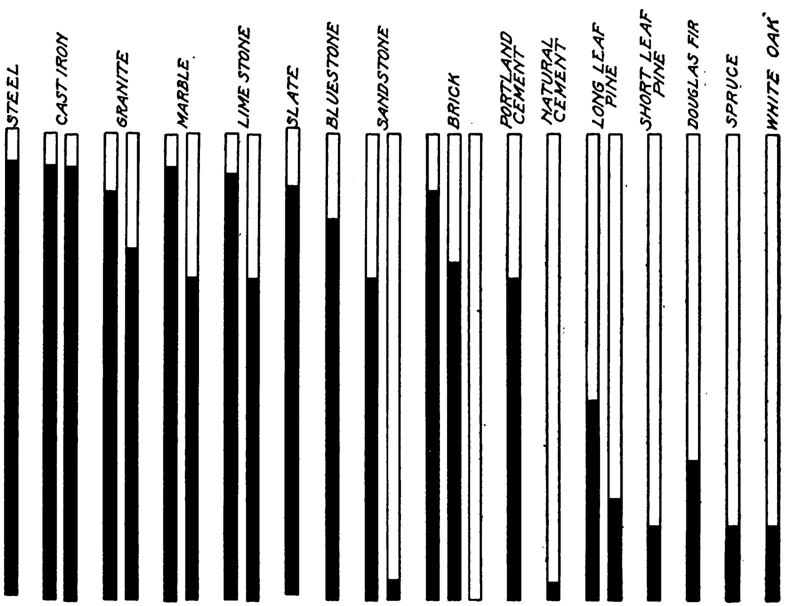


Fig. 77. The Relative Rigidity of Structural Materials

steels are strongest when cold, at 0° F. At lower artificial temperatures the strength is greater still. At about the temperature of boiling water the strength reaches a first minimum after which it increases to the crest at a zone in the vicinity of 400° to 600° F., after which there is a steady drop until the metal becomes plastic, at a bright red or yellow heat.

It appears from the best evidence available that the curves of elastic limits would not follow those of tensile strength, but show a gradual drop throughout as the temperature rises.

Fig. 79 shows the predicted expansive force which would be developed by confined materials when the temperature is raised. The figures on the diagram are based on the moduli of elasticity and the coefficients of expansion of the materials. A range in temperature of 160° F. was used, since this change in temperature will cause an expansion in a steel bar equal in amount to the extension which it will display under a stress of 30,000 pounds per square inch, that is, equal to the extension of a piece of mild steel at its elastic limit.

Steel pre-eminently leads in many of the physical constants and as here compared has a value quite beyond the other materials of construction.

The harder varieties of stone appear capable of developing an expansive force considerably above the softer stones of the same kind, which is due chiefly to the differences in their rates of compressibility under stresses.

Three predicted values are given for brick, to represent the behavior of hard, light hard and salmon brick. The very low value for salmon brick is significant. No results are presented on fire brick, but their properties resemble the underburnt building brick in that fire brick are quite compressible. They successfully resist the effects of heat, in part, because of the readiness with which they are compressed. Conversely, fire brick would not be expected to display a high expansive force when confined.

Lime mortar is very compressible and makes a good cushion in a wall for the stronger brick to act upon when heated. These expansive forces must be guarded against or may be neglected according to the kind of material or

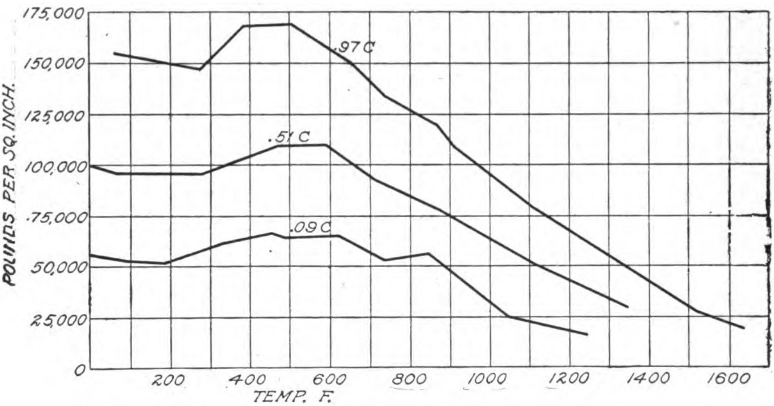


Fig. 78. Diagram Showing Tensile Strength of Steel at Different Temperatures

its position in the structure. It will be noted that the range in temperature here considered, only 160° F., is an exceedingly limited one; if, however, these predicted values are approximately reached the gravity of thermal changes in causing disrupting forces may be realized.

Fig. 80 shows the relative expansion of a number of building stones after exposure to a temperature of about 400° to 440° F. The open lines of the diagram indicate the approximate expansion of the stones when heated, while the portions showing full lines represent the permanent expansion which remained after they had returned to the initial temperatures. It will be seen from the results plotted on this diagram that stones when even moderately heated do not return exactly to their primitive dimensions, but retain as a permanent set some of the expansion which they acquired when hot. These permanent sets are comparatively small, amounting to but a few thousandths or ten-thousandths of the length of the sample, but, nevertheless, from the persistence with which they appeared in each case, are believed to be there.

If so they mean some change *in situ* the significance of which has not yet been explored. The change is taken to be a disrupting one, in its kind. It will be noticed that the permanent expansion of the marbles much exceeds that of the dolomites and that of the other stones represented.

Fig. 81 shows the loss in water and in carbon-dioxide of samples of ground hydrated cements. One Portland and two natural cements are represented, also a composite cement, silica brand, made of one part Portland cement and one and a half parts of crushed limestone. It is of interest to note that water of combination was successively driven off in this hydrated material as the temperature was raised from 230° F. to redness. This would seem to indicate a want of stability in the chemical state of the hydrated cement, or a state in which the equilibrium is disturbed at comparatively low temperatures. Hygroscopic water was driven off by initially heating the

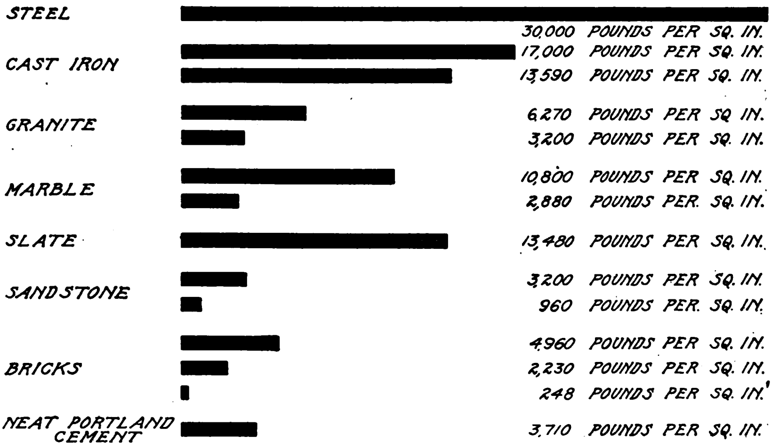


Fig. 79. Diagram Showing Relative Expansive Force of Confined Structural Materials when Temperature is Raised 160° F. Approximate, Predicted Values

material at 10° C. above the boiling point. The large per cent of carbon-dioxide driven off the silica brand of cement was due to the limestone used in its composition.

In this connection it may be remarked that cubes of neat Portland cement which were exposed to a temperature of 1000° F., within a short time thereafter gradually displayed cracks and eventually broke up into small fragments. The heating was done slowly, consuming one hour in raising the temperature, maintaining the maximum temperature for a period of one hour and then cooling the cubes in dry powdered asbestos. This careful treatment was adopted so as to avoid destructive internal strains by sudden changes of temperature, the object of the test being to determine the effect of exposure to successively increasing temperatures without endangering the integrity of the cement by violent thermal changes.

Fig. 82 shows the results of some temperature observations taken at the center of sticks of Douglas Fir wood, which were exposed over a wood fire for periods of two and one-half hours for each stick. One stick was quenched with water at the end of this period of time, another was smothered with sand and ashes, while the third stick was taken from the fire without quenching. The sticks originally were 10 inches square by 4 feet long. There was a hole bored at the center for a depth of 2 feet and a thermometer inserted in this hole indicated the temperatures which are plotted on the diagram.

It will be noted that no substantial rise in temperature was felt at the center of the sticks during the first hour over the fire. After this there was a rapid rise, which continued for some time after the sticks had been quenched or withdrawn from the fire. The temperature of the fire was estimated to be 1380° F. The sticks were burned until they were from 6 to 7 inches square.

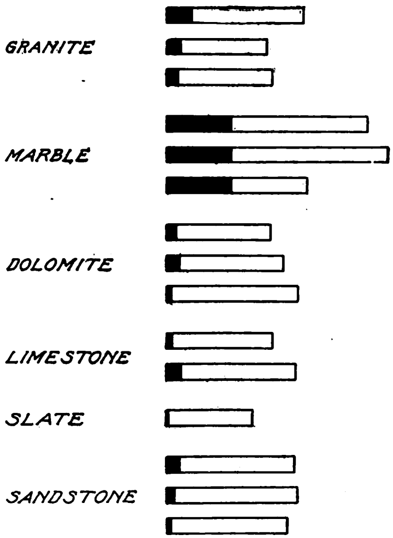


Fig. 80. Diagram Showing Relative Permanent Expansion of Different Building Stones After Heating to a Temperature of About 400° to 440° F.

Compression tests made on the wood after scraping off the charred portions showed the unburnt portions to have retained their strength unimpaired. In fact the thorough drying of the core was to its advantage apparently since the compressive strength of the central portions gave results above the average for this kind of wood. Some long leaf pine posts, charred by a fire which occurred in the upper story of a building, also displayed compressive strength equal to, and in some sticks above, others from the same building which had not been charred by fire.

Fig. 83 shows other sticks of Douglas Fir wood which were exposed over a wood fire in the same manner as those the results of which were plotted on the previous diagram. The treatment was varied; those represented on the present diagram had alternate periods over the fire. One stick was quenched with water after having been over the fire for one and three-quarters hours and immediately returned to the fire, which operation was repeated five times; after the sixth quenching it was cooled in the air. The other stick was exposed to the fire alternate hours for three hours, then taken from the fire and smothered.

Fig. 84 shows the compressive strength of a group of columns of different kinds of structural materials. The compressive strength of steel columns is given at 30,000 pounds per square inch, an ordinary strength for structural steel. It may vary from this according to the grade of steel used, lower or higher according to the elastic limit of the metal, and modified by the workmanship.

The compressive strength of cast-iron columns has been found in the vicinity of 30,000 pounds per square inch also. This metal occasionally gives higher results and at times lower. The uncertainty of having an unsound casting is a source of trouble and detracts from the reliability of cast iron.

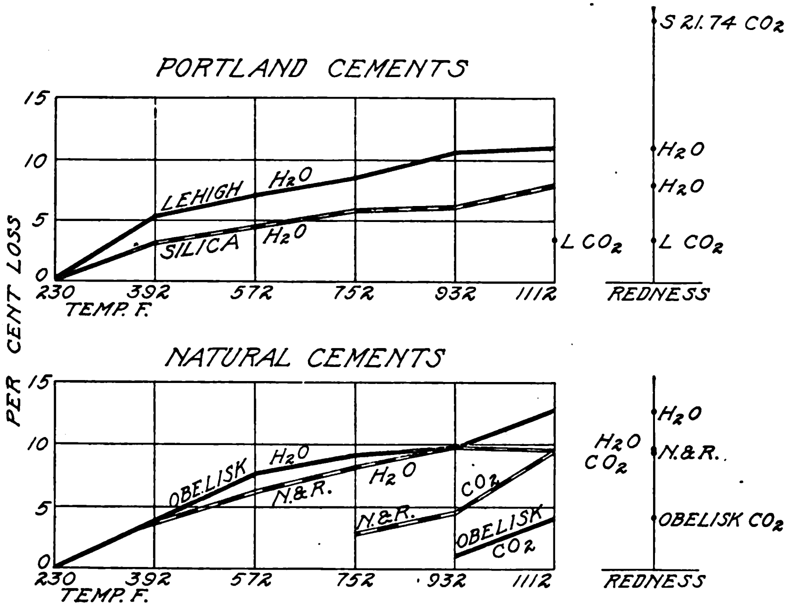


Fig. 81. Loss in Water and Carbon-Dioxide of Ground Hydrated Cements when Heated to Different Temperatures

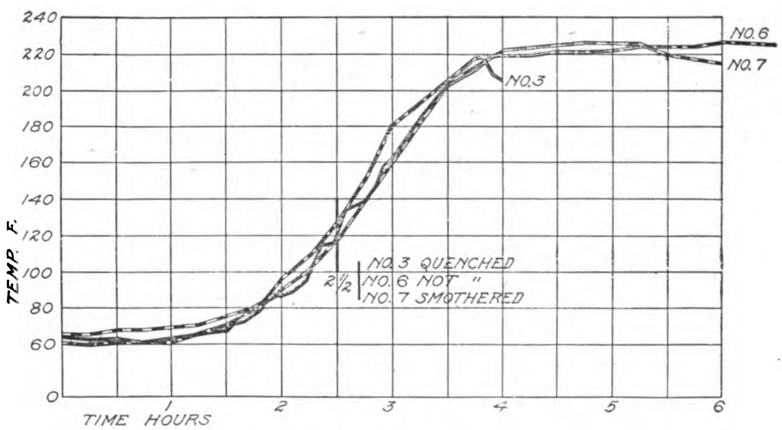


Fig. 82. Heat Conductivity of Douglas Fir Sticks—10 in.×10 in.×4 feet

The strength of individual brick greatly exceeds that of brick when laid in piers. This is due largely to the grade of mortar employed. Hard burnt brick frequently ranges in strength from 15,000 to 20,000 pounds per square inch when tested singly and an exceptional shale brick was found to possess the phenomenal strength of 38,000 pounds per square inch.

In piers, however, a compressive strength of 3,000 pounds is a very strong one, although when a hard brick is laid in neat cement, a resistance of between 4,000 and 5,000 pounds may be displayed. The same grade of brick laid in lime mortar will develop only about 1,500 pounds per square inch ultimate strength. Light hard brick shows less difference in strength whether laid in neat cement or in lime mortar. It develops lower strength than the harder brick and being nearer the strength of the lime mortar the cushioning of the mortar is more favorable relatively. Provided the stronger brick could be laid in mortar having nearer the characteristics of the brick, then a much higher strength might reasonably be expected. Sand lime brick ranges in strength from 1,500 to 3,000 or 4,000 pounds.

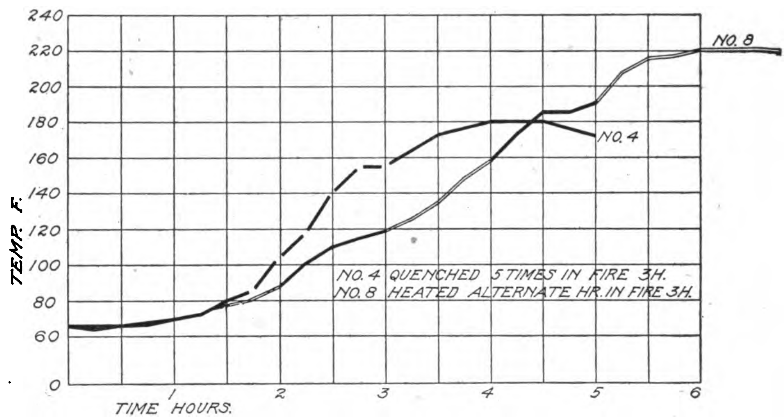


Fig. 83. Heat Conductivity of Douglas Fir Sticks—10 in. × 10 in. × 4 feet

The strength of mortar composed of Portland cement depends upon the richness of the mixture. The diagram illustrates the range which may be expected in mortars from a one and one mixture to a mixture containing one part Portland cement to five parts of sand. The rigidity of these mortars is approximately in proportion to their strength. The strength of concretes follows about the same as that of the cement mortars. The addition of the stone has been found not to modify the ultimate strength over wide ranges. Some examples have shown a slight loss in strength of the concrete over that of the mortar used without the stone, and illustrations of the opposite kind may also be found.

Occasional sticks of long leaf pine are found which develop the maximum strength plotted on the diagram, but a common strength is in the vicinity of 4,000 pounds per square inch, while 3,000 pounds is an ordinary value for short leaf pine. Douglas Fir has generally a compressive strength of about 4,000 pounds per square inch. These values are such as may be found, but the wide range in ultimate strength which is displayed by structural materials makes it necessary to consider specifically the properties of those materials which are actually to be used when judging of the strength of any particular structure.

RETARDING FIRES

On erecting a new building it is senseless to do the thing half-way. There is but one really sensible way of doing and that is to build properly. But we are confronted with the fact that there are millions of old buildings still with us, firebreeders, conflagration starters and feeders. They are being torn down, burnt, replaced with new;

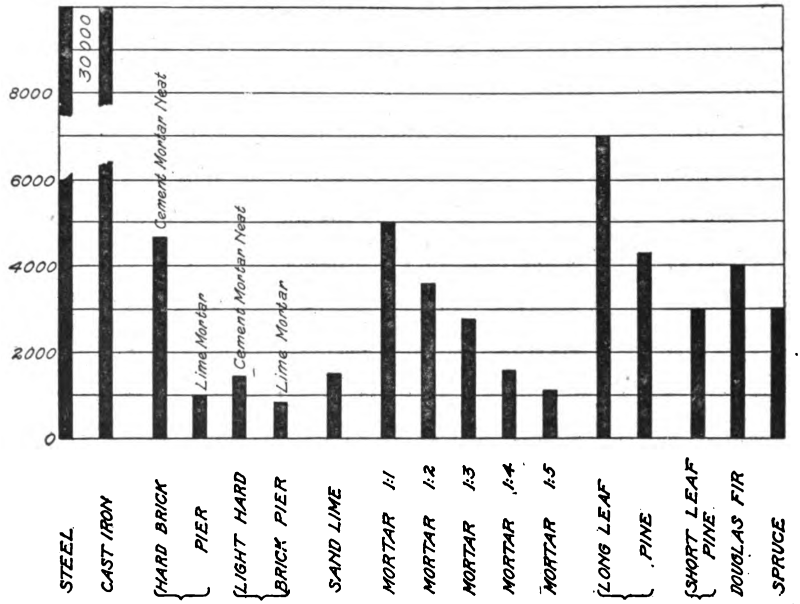


Fig. 84. Compressive Strength of Columns of Different Structural Materials

true, but still millions of them will remain with us for yet many a year. Some are important, expensive buildings, it is doubtful if their owners would ever deliberately tear them down, while they might be perfectly willing and anxious to do all they could to make them less dangerous, less burnable.

Upon the assumption that "every little helps,"—and it does unquestionably—there are many things which can be done to a building which will retard fire and which in themselves are not over-costly or hard to install. Study out where fire is most apt to originate and there take extra precautions to nullify that possibility. For instance, in the boiler room, which may be only a basement and not adapted for the purpose, put in a brick wall dividing it from the rest of the basement, suspend a wire lath and plaster ceiling below the wood joists and vent the space between the two, or suspend tile below those joists or even tin that ceiling, or better still fasten on a lining of asbestos-sheeting. In any other room where fire is most apt to start get a suspended plaster ceiling up, well away from the present ceiling, or put on an ornamental metal ceiling. See to the outside openings, get metal sash and wire glass into exposed windows and skylights, and put fire doors where needed. Look to the roof; if it is shingle get on something better, asbestos shingle, or metal. Rip out the old wooden stair at any cost and get in an enclosed fireproof stairway direct to the street. We placed emphasis upon a good stairway in a fireproof building, and surely such a stair is needed still more in this old building. Affix fire-escapes at accessible points, or provide portable ladder fire-escapes that may be dropped from any window—a most serviceable and commendable escape that should be in every corridor if not in every room of a hotel, factory, or other such building, and one in every home. Study out the purpose of that building and its potential fire risk and cut it up into units as much as possible; even a wooden door is better than a clear runway for fire. Keep in mind what a perfect fireproof building ought to be and then get this old building into a condition as near fire-resisting as possible. Nothing can save that building in a conflagration if fire can get *into* it; but you may be able to do so much to it externally as to even make it invulnerable to that attack. The external protection—given fairly good brick walls and other than a shingle roof—is the easiest and most simple thing to do with the whole problem. And internally the one great object ought to be to restrict fire to some one space, to retard it, to offer it as little igniting fuel as possible, so as to afford an opportunity to the fire department or the people in the building to get to work and control that blaze.

Even a fireproof (?) paint of reputable make is of some little value. Anything that will coat the surface of wood so that it will ignite less quickly than bare, or oiled, or painted wood is commendable. Remember, though, that nothing can *proof* wood, the wild

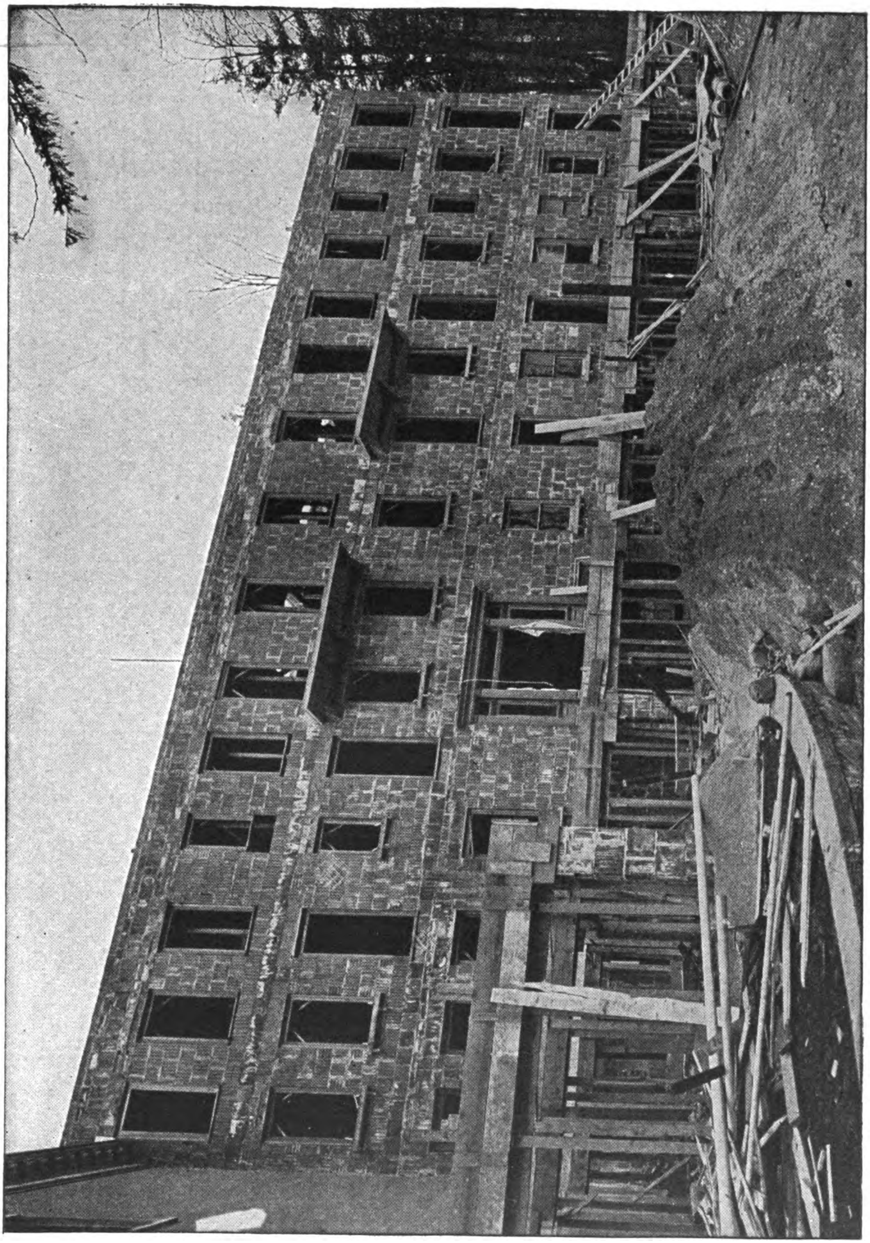


Fig. 85. Building Hollow Tile Apartments

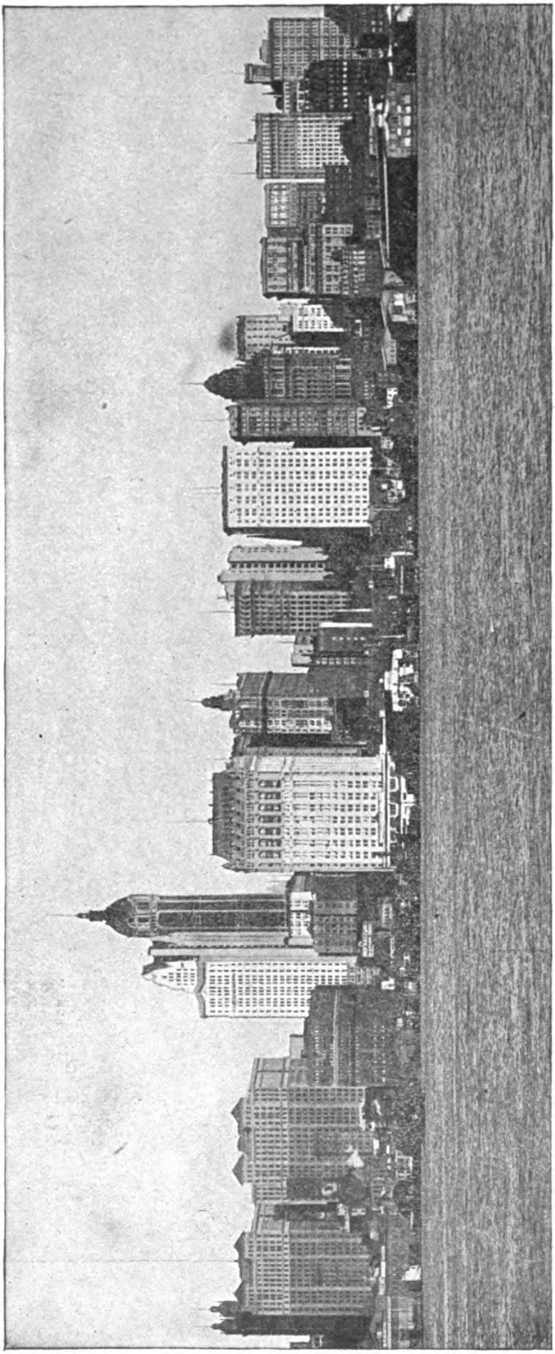


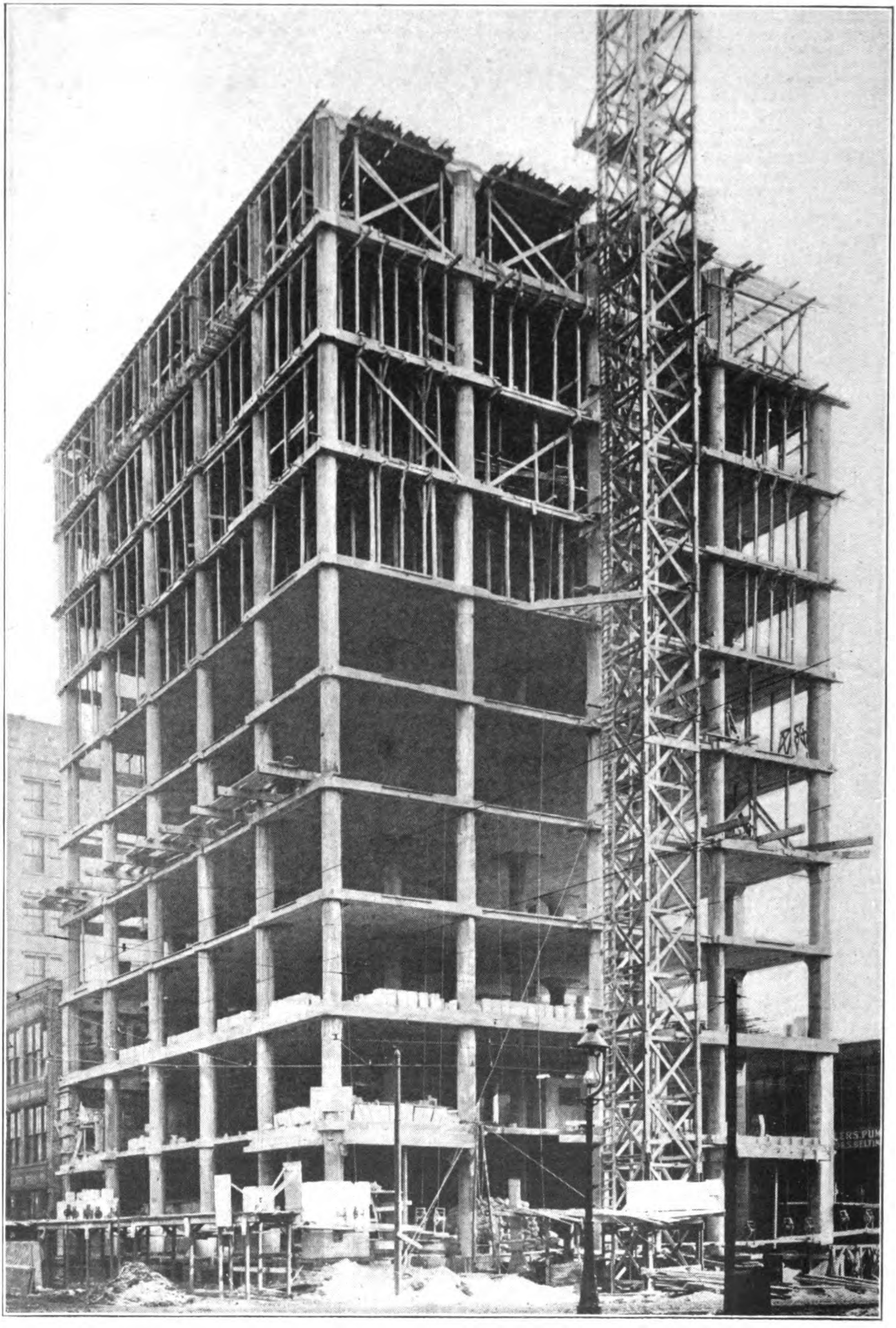
Fig. 86. The Skyline of New Ycrk City

(Copyright by Underhill, N. Y.)

The tallest and best constructed buildings in the world, yet not ideally fireproof, in that in nearly every one of them something was neglected or done as it should not be just enough to jeopardize even the structural parts. But a little if any additional expense, though considerably more intelligence than was shown would have been necessary to make them properly and absolutely immune to fire.

advertising of certain companies and the approval of certain government "experts" to the contrary notwithstanding. A few years ago there was a veritable craze for "fireproof" wood—it simply shows the power of reiterated and attractive advertising—wood that had been put through some chemical process, the sap expelled and the pores or texture impregnated with saline or other chemicals. It was supposed to make it as incombustible as metal. It did retard ignition but if exposed a while to a blaze it soon went the way of all vegetable growth, into smoke and ashes. But all those things *will* and *do* retard fire's progress a little. Sometimes a minute even is all that stands between salvation and destruction. Therefore, it behooves us to gain that minute by applying the "retardants" where nothing better can be done.

And finally, much of the advice previously given simmers down to a plea in behalf of a something, not essentially a building material either, but something very necesssary in building fireproof buildings—*good common sense.* We can say, do thus and so, but in that and all else you must finally resort to that common sense. No prescription blindly followed, is all-sufficient; you must mix it well and stir it with that aforesaid common sense and take it in very large doses. Do not do this and that because John Smith did it. Study why he did it and what was actually the result, and if what he attempted was really accomplished, or if he was but playing with a theory. Ask yourself whether the proposed building may ever be exposed to a conflagration, what its chief internal dangers will be, how it may be jeopardized by its neighbors, get your problem well in mind. Study all you can find written upon fire. Study fire; examine buildings after a fire; note the difficulties there were in extinguishing that fire, for instance, that the deep beams and girders in the ceilings deflected the water and allowed the fire to burn with greater fierceness back in the room; study the tests made by the underwriters, the city building departments, manufacturers; collect everything you can about fire, and with avidity, reason out the whys and wherefores in all these points and digest them; and when a problem in fireproofing presents itself, apply what you have heard, along with a large proportion of common sense, and that problem, however involved and difficult it may at first appear, will be as simple to you as $2 + 2 = 4$.



SHARPLES BUILDING, CHICAGO, UNDER CONSTRUCTION
William D. Mann, Architect; T. L. Condron, Engineer

FIREPROOF CONSTRUCTION

PART IV

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*CONCRETE FROM THE FIRE-RESISTING STANDPOINT

It is of the greatest importance to learn as much as possible about the permanence of materials that are to be used in building construction before incorporating them into structures intended to be practically permanent in character. There are many destructive agencies at work all of the time that reduce the strength and impair the life of structures. Decay and rust, for example, are constantly at work, effecting the most serious depreciation in buildings, and, while stone masonry does not decay nor rust, it does disintegrate when exposed to the action of rain and frost. Frequently stone used in the fronts of buildings cracks and crumbles to such an extent as to make it necessary to tear it down, as was the case with the Post Office and Court House buildings in Chicago a few years ago.

Concrete as a Building Material. *Portland cement concrete* is an artificial stone, consisting of broken stone, gravel, and sand, and other inert materials of varying sizes, mixed with Portland cement and water in such proportions that the mixture will set or harden into a compact mass. If the aggregates used are properly graded as to sizes and well mixed with sufficient cement to thoroughly bind them together the resulting concrete will be very dense and hard and will become harder and stronger with age.

Reinforced Concrete. Reinforced concrete is made by incorporating steel in the form of wires, bars, or expanded metal in the concrete to resist tension stresses. This forms a building material that has the best characteristics of both stone and steel and is superior to either of these because it will not be affected by the disintegrating influences of frost and rust; for the steel will resist the cracking of

*With special reference to Reinforced Concrete in Building Construction.

the concrete by contraction and the concrete will protect the embedded steel against rust.

Behavior under Fire. In addition to the destructive agencies of decay, rust, and frost, there are also the injury and destruction due to fire. Fire in our country probably destroys more building property annually than all the other agencies put together because we have used so much combustible material in our buildings and have neglected to take advantage of the various means of fire protection and fire prevention.

No building material will withstand fire or a high degree of heat, for a prolonged period without material damage or complete destruction. Some building materials, such as wood, are consumed by fire and, therefore, furnish fuel to the flames; other materials, such as steel, while not consumed, readily warp and twist and are weakened by heat, and, therefore, become incapable of carrying their loads, resulting in the collapse of parts of buildings and a consequent spread of fire; other materials such as clay tile are incombustible and good non-conductors of heat, but are fragile and, therefore, suffer materially from heat when restrained against free expansion; materials such as glass have a relatively low melting point as well as being fragile so that they either melt or break when subjected to excessive heat; still other materials, such as brick when well laid in good mortar, are practically *fireproof* although heat and water combined will cause their mortar joints to open and their surfaces to spall to some extent; and, finally, another material is Portland cement concrete, which is incombustible; a material that heat does not soften, warp, or melt; a material that is not fragile and, therefore, not liable to be shattered because of unequal expansion, but a material resembling brick, the surface of which will be injuriously affected by prolonged heat but the body of which will be uninjured by any ordinary fire in a building.

Quality of Concrete. Concrete when used as a building material, in places where resistance to fire is essential, should be Portland cement concrete and the proportion of cement used should be such as to thoroughly cement the aggregates together. In other words, like all other building materials the quality of concrete should be good, as bad concrete is like bad brick or bad timber—except, unlike bad timber, even bad concrete does not deteriorate with age.

In reinforced concrete for buildings, the amount of Portland cement should be between one-fifth and one-fourth of the entire volume of the concrete. Portland cement may be briefly described as a definitely-proportioned and finely-ground mixture of calcareous (limey) and argillaceous (clayey) materials, burned or semi-fused to a clinker, which clinker is reground to a very fine powder. This powder is the cement and has the property of setting or hardening under water or when mixed with water. It will thus be seen that the cement itself has been "tested by fire." The aggregates used in such concrete are usually sand and broken stone or gravel, although sometimes crushed slag or cinders or broken bricks are used in place of stone or gravel. In different localities different aggregates are used, one important feature of concrete being that concreting materials are found in every locality and obtained at small cost. Portland cement, unlike steel, is now manufactured at so many centers in the United States that the cost of cement delivered is nowhere prohibitive to its use and generally its cost delivered is so low as to stimulate an ever-increasing demand.

Construction Developments Due to Concrete. *Early Forms.* The wide use of reinforced concrete has led to entirely new forms of construction peculiarly adapted to that material. The earlier forms of floor construction carried out in wood have continued for centuries, and consist of planking laid flat upon joists, the joists being supported directly upon walls or by beams or girders running at right angles to the joists and in turn supported by walls or columns. Such construction presents a broken ceiling surface giving opportunity for dirt and dust to collect and exposing a large surface for fire to attack. In order to obtain a flat ceiling, a ceiling surface is usually hung from, or rather nailed to, the under edges of the joists, making a series of enclosed pockets between floor and ceiling that may become breeding places for vermin. With the introduction of iron and steel beams in building construction, beams and girders of these materials replaced those of wood and, likewise, iron and steel columns were often used instead of wooden posts to support the beams. As iron and steel became cheaper and demands for better construction grew, ways were devised for replacing wooden floors with "fireproof floor construction." An early but very faulty type of so-called fireproof floor consisted of brick arches between the iron beams with the bottom flanges of the beams exposed. These floors were of tremendous weight and very expensive, and the lower flanges of the beams being exposed to the action of fire would expand and probably fail in fire. In order to reduce weight, the hollow tile arch was introduced, and tile soffits were provided to protect the beam flanges. Even this construction followed the lines of wood floor construction, iron beams replacing the wooden joists, and the tile arches replacing the flooring boards, thus permitting the iron beams to be spaced 4 to 5 feet apart instead of 12 or 16 inches, as in the case of the wooden joists supporting plank flooring.

Applications of Concrete. With the advent of reinforced concrete about ten or twelve years ago—for it is as recently as that that it has been used to any extent in this country—the same type of floor construction was followed as in the case of wooden and tile floors, only a concrete slab took the place of the boards or hollow tile

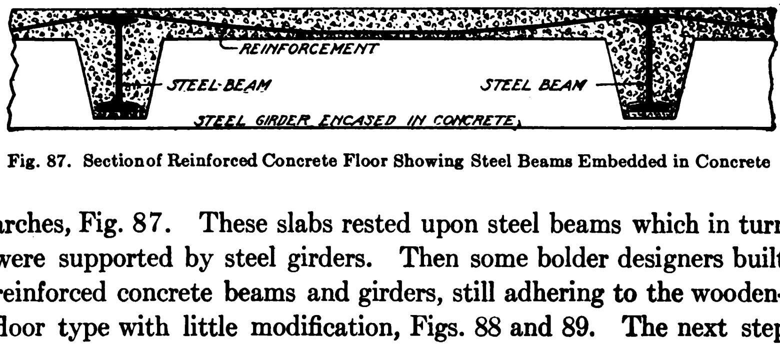

Fig. 87. Sectionof Reinforced Concrete Floor Showing Steel Beams Embedded in Concrete

arches, Fig. 87. These slabs rested upon steel beams which in turn were supported by steel girders. Then some bolder designers built reinforced concrete beams and girders, still adhering to the wooden-floor type with little modification, Figs. 88 and 89. The next step was the long span slab, doing away altogether with the joists and making slabs of 12- to 20-foot spans carried directly on the walls or girders without subdividing the panels by beams or joists, Figs. 90 and 91.

There was also developed a combination of tile and reinforced concrete slab for long span slabs, which has usually been used with structural steel girders, Fig. 92. It has several points in its favor but it is a lamentable fact that nearly all of the so-called "failures of reinforced concrete" floors have occurred with this form of construction. One of the objects of this construction has been a flat ceiling without the trouble and expense of an independent suspended ceiling. Also the cost of form work may be reduced in some cases

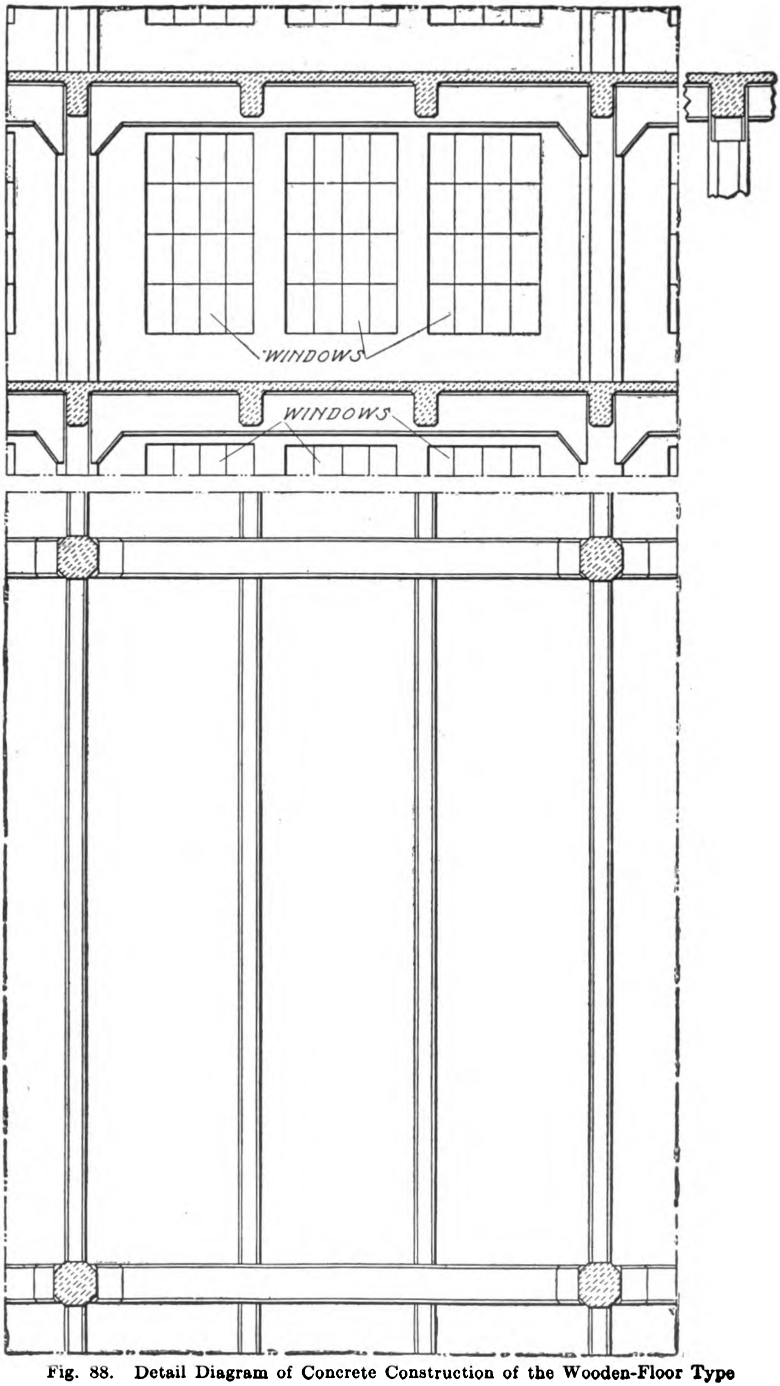

Fig. 88. Detail Diagram of Concrete Construction of the Wooden-Floor Type

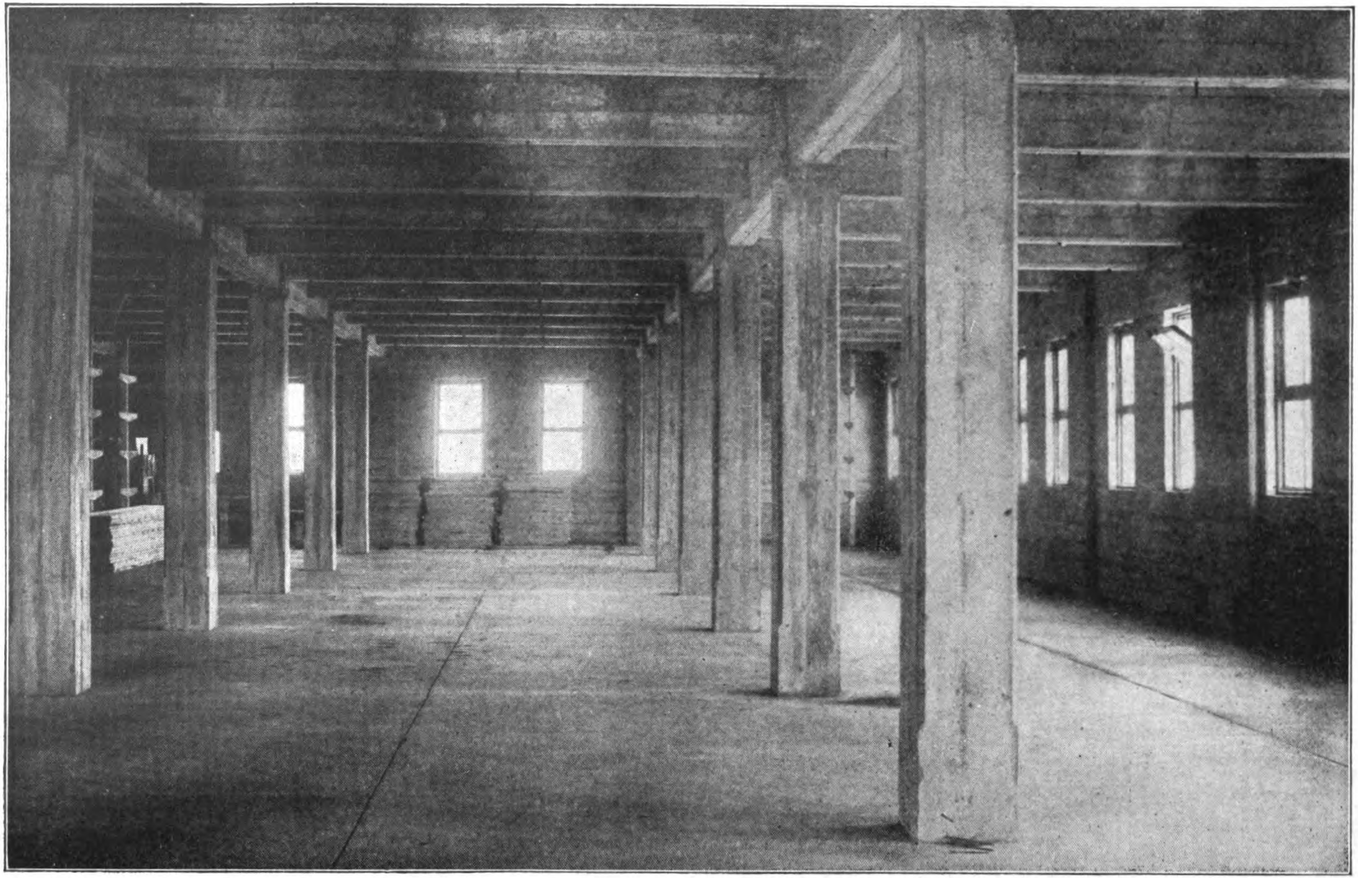

Fig. 89. Reinforced Concrete Building Showing Floor Construction of the Wooden-Floor Type

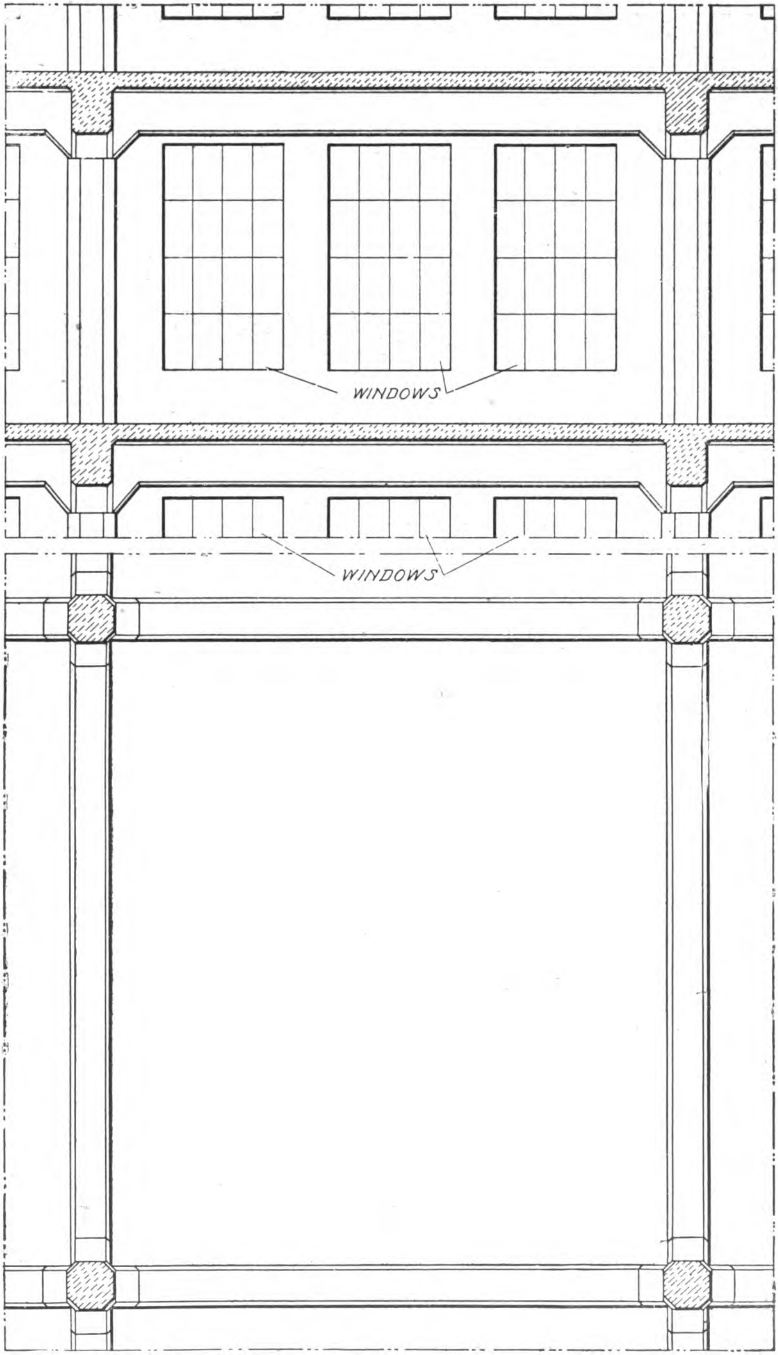

Fig. 90. Reinforced Concrete Floor Construction of the Girder and Slab Type

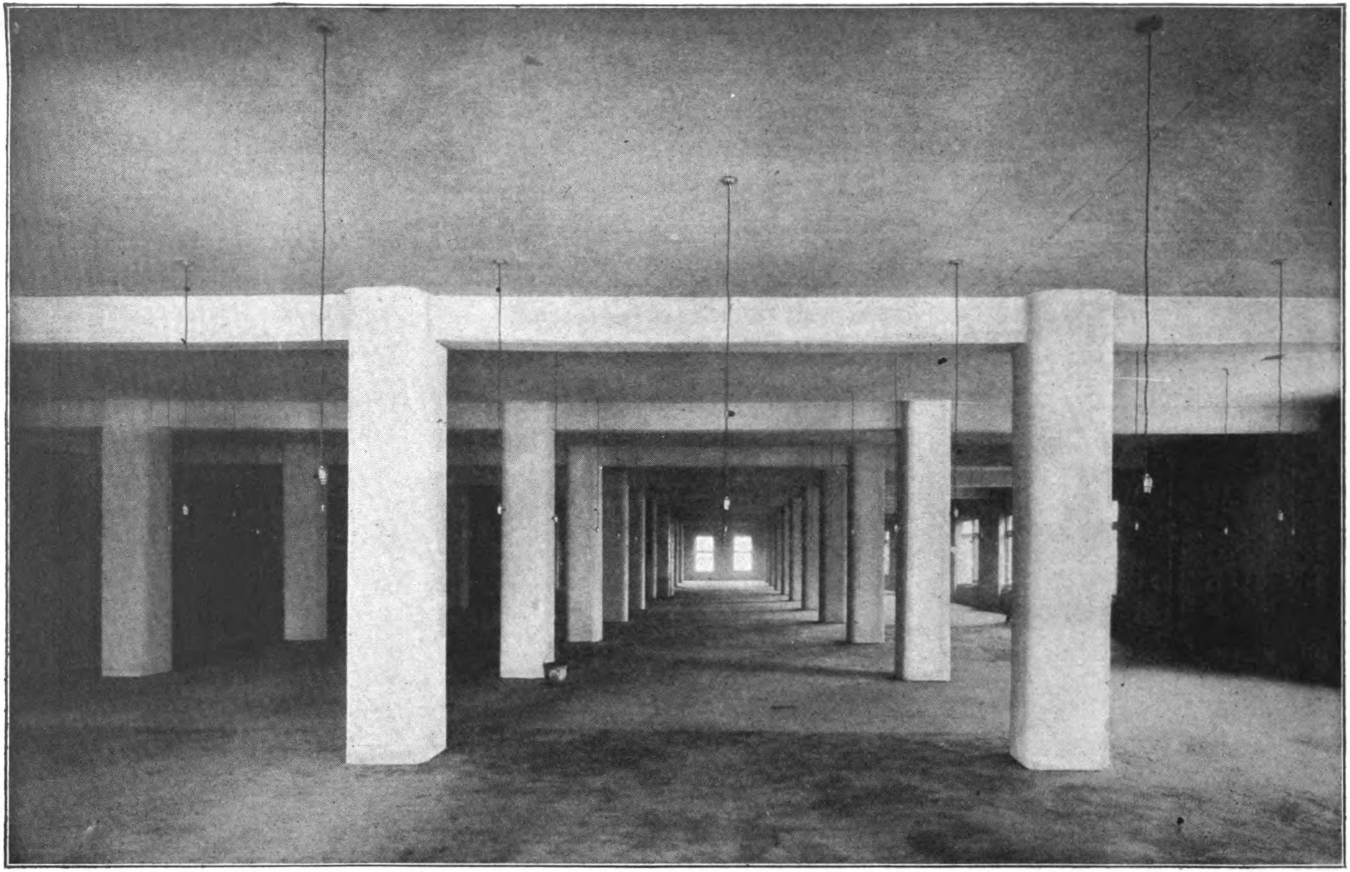

Fig. 91. Reinforced Concrete Construction Showing Girders in One Direction Only and Long Span Slab

because of lighter construction. None of these types of construction, however, were other than applications of reinforced concrete to forms of construction developed for other materials.

The complete continuity, or the monolithic character of reinforced concrete construction has resulted in a type of floor peculiar to this material and one that could not be built economically of other materials, that is, the girderless and beamless type; this is illustrated by the so-called "mushroom" type, Fig. 93, designed by C. A. P. Turner, and by the paneled-ceiling type, designed in the author's office, a finished example of which is shown in Fig. 94, and work under construction in Figs. 95 and 96. Decided fire-resisting advantages are gained in these types of reinforced concrete construction because of the absence of deep girders and beams with their inherent exposures of edges and corners, and ceiling pockets to collect the heat of a fire and to deflect the stream of water from

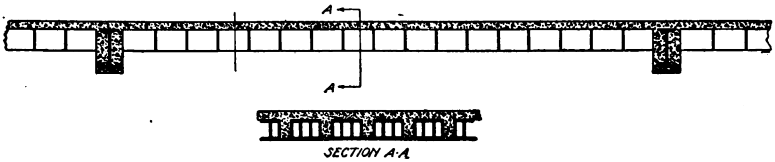

Fig. 92. Floor Section Showing Combination Tile and Reinforced Concrete Construction

a fire hose. In addition to these advantages the paneled-ceiling type reduces the dead weight of the structure and gives a very pleasing architectural effect.

Fire-Resisting Qualities. In discussing the fire-resisting qualities of concrete, three questions present themselves, viz,

(a) *What security does reinforced concrete construction offer against fire loss?*

(b) *Is any vital element of the structure exposed to injury in case of fire?*

(c) *What injuries have resulted from fires in reinforced concrete buildings?*

In general, the greatest injury from fire may be looked for on the under side of floors and beams. Fortunately, the concrete on that side is considered only as fire protection for the reinforcing steel and not as adding strength. If the concrete below

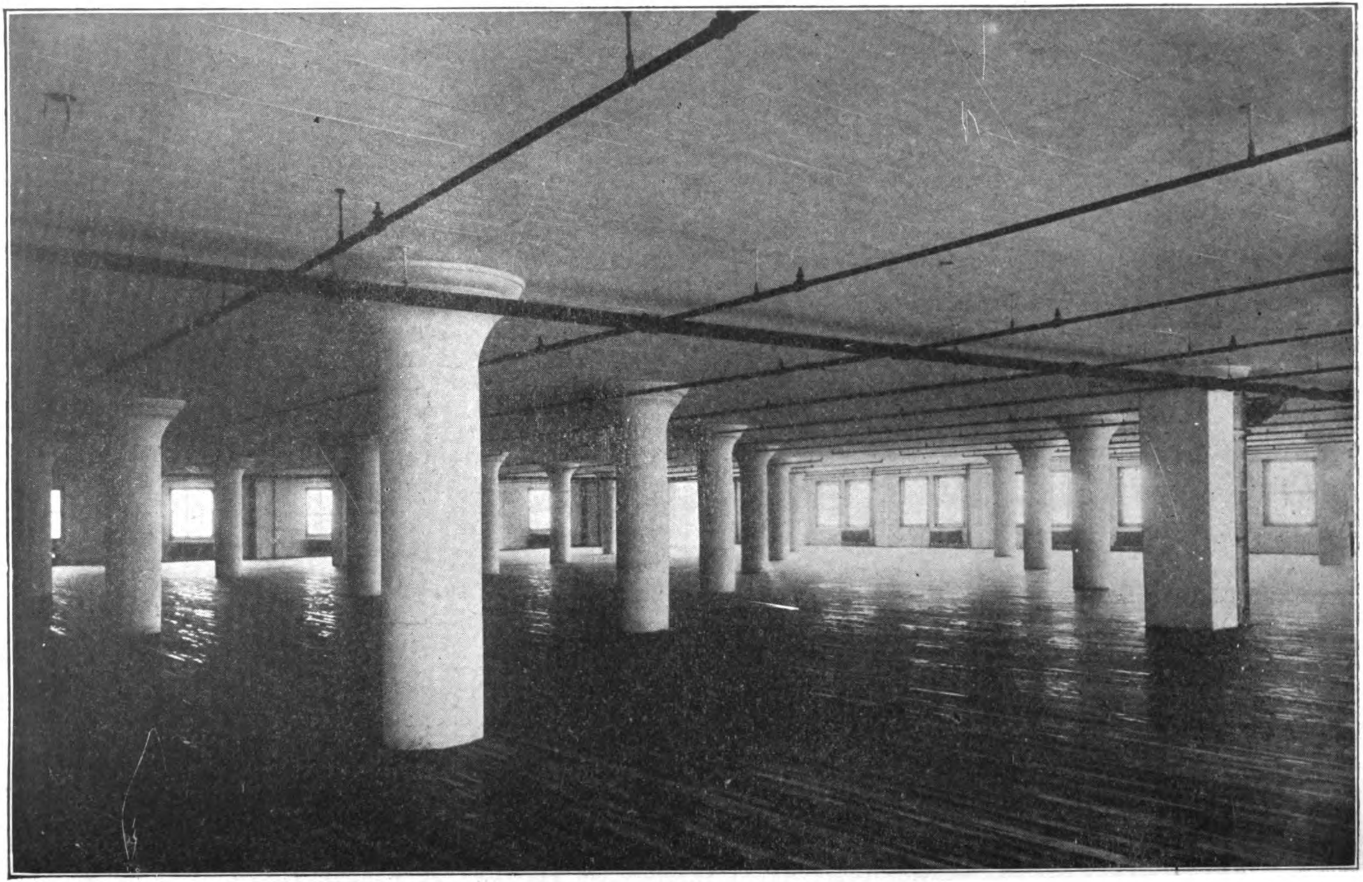

Fig. 93. Reinforced Concrete Warehouse Showing Turner's Mushroom System

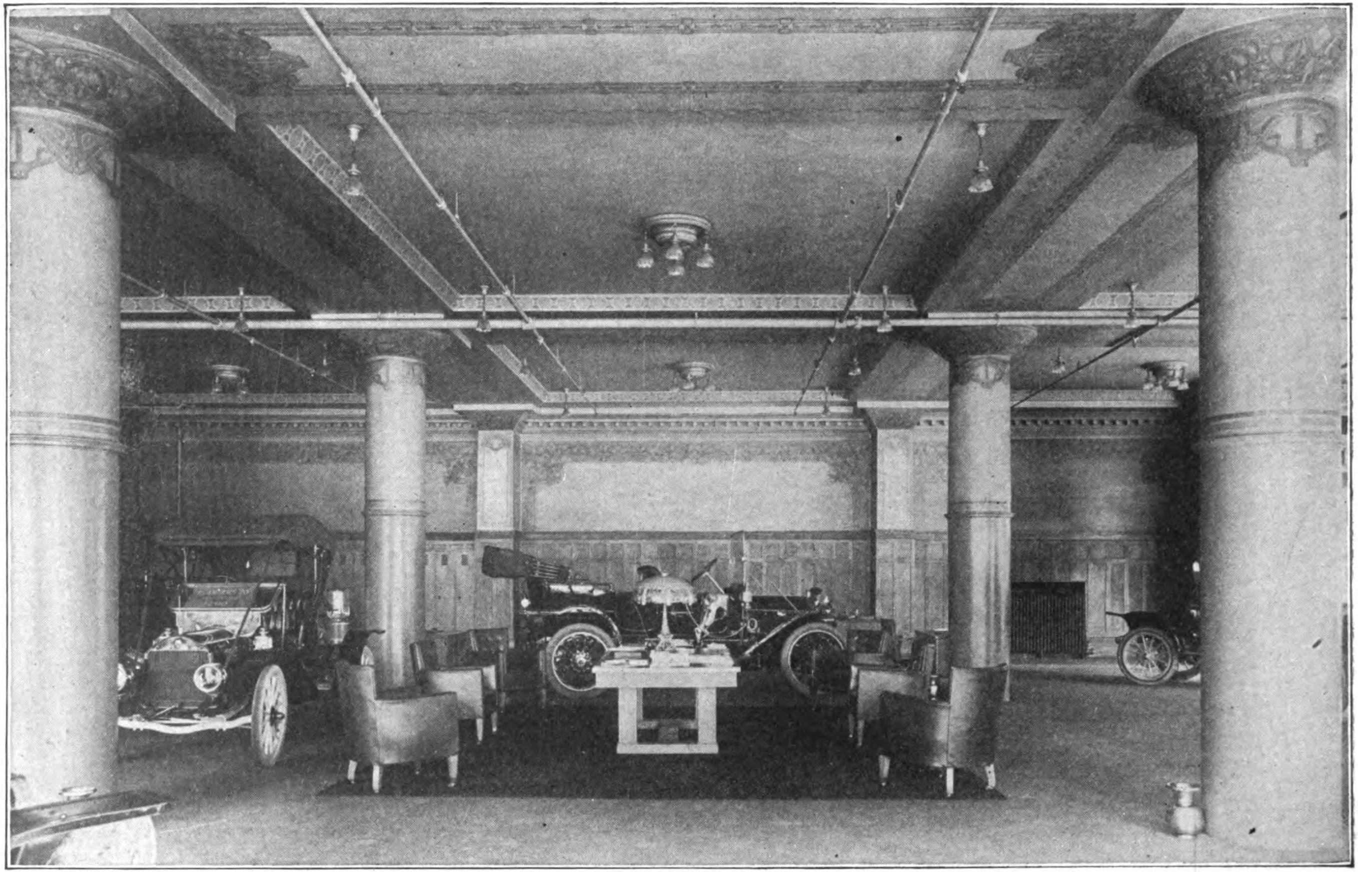

Fig. 94. An Approved Type of Fireproof Building, Reinforced Concrete Panel Slab Construction, "C & S Type," with Automatic Sprinklers

the reinforcement protects the steel bars from the effects of fire by remaining in place long enough, it serves its purposes and no material injury will happen to the structure as a whole, for this lower concrete can easily be repaired. If, however, the lower concrete is not an efficient protection to the reinforcing steel, reinforced concrete will be found deficient as a fire-resisting material.

It has been stated that "generally speaking" the concrete on the lower side of a floor is considered only as fire protection for the

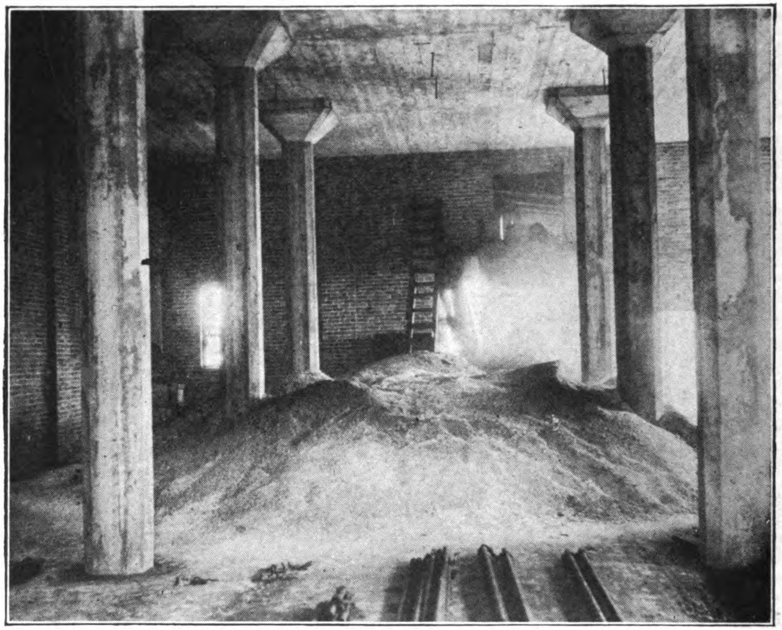

Fig. 95. Reinforced Concrete Flat Slab Construction for 400 Pounds Per Square Foot Live Load, "C & S Type"

reinforcing steel. There is a marked exception to this rule in the most approved reinforced concrete construction, for here the under side of the floor construction is not in tension from support to support as is the case in ordinary wood and steel construction. In fact, in the best floor designs the tension stresses occur on the under side only in the middle half or middle third of the span and in the remainder of the span the tension stresses occur on the upper side; consequently, in such designs the larger part of the tension reinforcement is near the upper surface where it will be least affected

Fig. 96. Reinforced Concrete Paneled Slab Construction, "C & S Type"

by the action of fire. In these cases, from one-half to two-thirds, or even three-fourths of the under side of a floor panel is in compression and here injury to the lower surface of the concrete simply reduces the effective depth of the construction and tends to increase the compression stresses in the uninjured concrete.

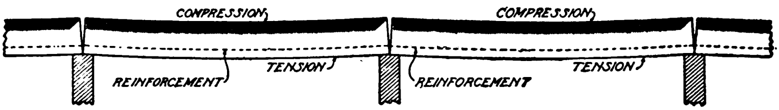

Fig. 97. Series of Disconnected Beams or Slabs Resting on Supports and Deflecting Under Load

Two illustrations will make clear the distribution of stresses referred to, which follows the well-known laws of stress and strain. Fig. 97 illustrates the usual case of wooden and steel beams in buildings and of non-continuous reinforced concrete beams; Fig. 98 illustrates the arrangement of the reinforcement in reinforced concrete beams, whereby the structure is made continuous over supports. In case of fire below such construction as illustrated in Fig. 98, the complete stripping of the concrete below the lower reinforcing bars and the stretching of these bars would not result in collapse, for the structure would hold up through the cantilever action of the portions over the supports. However, this condition could result only from a very serious conflagration.

What do the records of fires in reinforced concrete buildings show as to the resistance of such construction to fire? Notwithstanding the great extent to which reinforced concrete has been applied to building construction in this country during the past ten

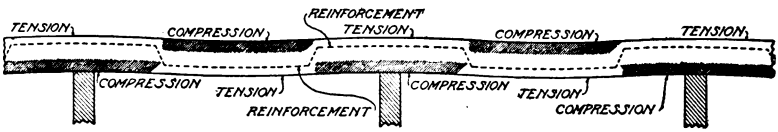

Fig. 98. Series of Connected Beams or Slabs Continuous Over Supports and Deflecting Under Load

years, there are comparatively few examples of serious fires affecting reinforced concrete structures and the dire prophecies of some pure theorists and enemies of concrete seem never to have been fulfilled. The author has collected as many reports as possible of fires in "fireproof" buildings and has been greatly impressed by the fact that while the records are full of terrible catastrophes and tremendous losses in buildings of all other types of construction, there is an utter absence of serious results recorded in connection with concrete buildings.

Certainly but one conclusion can be reached from the study of the records, viz, that concrete is a reliable and safe building material and will give a better account of itself in a case of fire than any of the other commonly used materials. That this fact has been impressed upon owners of concrete buildings is shown by the statement published by the Turner Construction Company of New York, after making a canvass of 1,000 owners of concrete buildings, that they find 266 of these owners who carry no insurance on their buildings, thus showing the confidence they have in the fire-resisting qualities of their structures.

The cost of reinforced concrete buildings is but a little more than the cost of "mill construction"—that is, buildings with brick walls and wooden floors carried on wooden or iron columns—and the cost of reinforced concrete construction is much less than that of steel frame buildings with fireproof floors. Therefore it is evident that this form of construction, having been proved the most fire-resisting of any building construction yet devised, will continue to grow in popularity and with the natural betterment of both designs and workmanship it will gradually supplant not only "mill construction" but the older forms of fireproof construction. In view of the extreme flexibility of this wonderful material it is hard to imagine what more improved building material can be devised to rival reinforced concrete.

Selection has been made from the available records of the most serious fires in concrete buildings and they are presented here in brief so that the reader may learn what effect fire has had on buildings of this construction. The results of these actual fire records in concrete buildings and the results of the experiments made by the United States Geological Survey have been given as direct quotations from those who personally examined the structures and from the reports made by Richard L. Humphrey, who personally conducted the government experiments, in preference to making general statements and unsupported claims for the fire-resisting properties of reinforced concrete construction. To those who have studied the subject, none of these reports will be new but even to them it will perhaps be interesting to have the facts regarding the behavior of concrete brought together in logical order and in condensed form.

FIRE RECORDS AND TESTS

"CONCRETE" FIRES

Peavey Elevator Company. In *Cement* for May, 1906, appears the following description of the fire at the Peavey Elevator Plant at Duluth, Minnesota:

"Recently a fire occurred in the plant of the Peavey Elevator Company at Duluth, Minnesota, the plant consisting of wooden buildings and a battery of thirty concrete grain storage tanks. The wooden buildings contained nearly a million bushels of grain which, with millions of feet of lumber, burned quickly, Fig. 99, and produced a terrific heat, sufficient to keep the fire fighters several hundred feet away. The steel structure connecting the buildings was fused at an early stage. The nearest line of concrete tanks was but 35 feet away, and the tanks withstood the conflagration without the slightest injury to the concrete or to the grain stored in them.

"Fig. 100 shows the fire when practically over and also the nearest line of concrete tanks."

Huyler Candy Factory. In the *National Fire Protection Association Quarterly* for January, 1908, there appears the following record of the fire in the Huyler Candy Factory, New York:

"The fire was confined to the storage compartment, where it originated, its fuel being furnished by empty paper candy boxes and tall piles of flat paper stock; also a considerable amount of light woodwork in the form of shelves, racks, and partitions. On account of the tightness of the compartment and consequent accumulation of smoke and gases, the fire was fought with great difficulty as hose streams had to be used at close quarters from the fire-door openings and through two holes broken through the ceiling. The rapid prostration of the firemen from the effects of the gases prevented quick control of the fire.

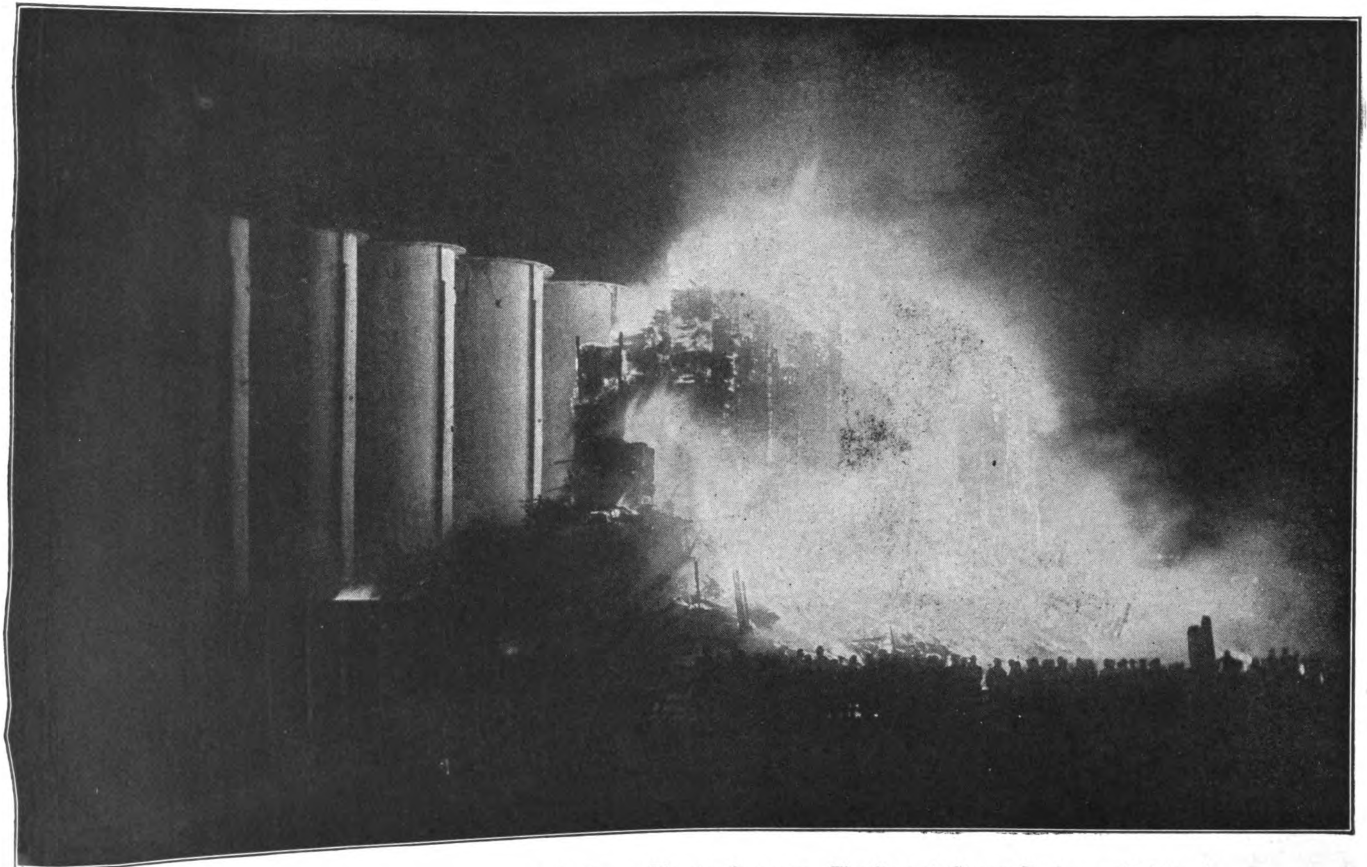

Fig. 99. Destruction of Wooden Elevators of the Peavey Elevator Company. The Concrete Storage Tanks were Uninjured

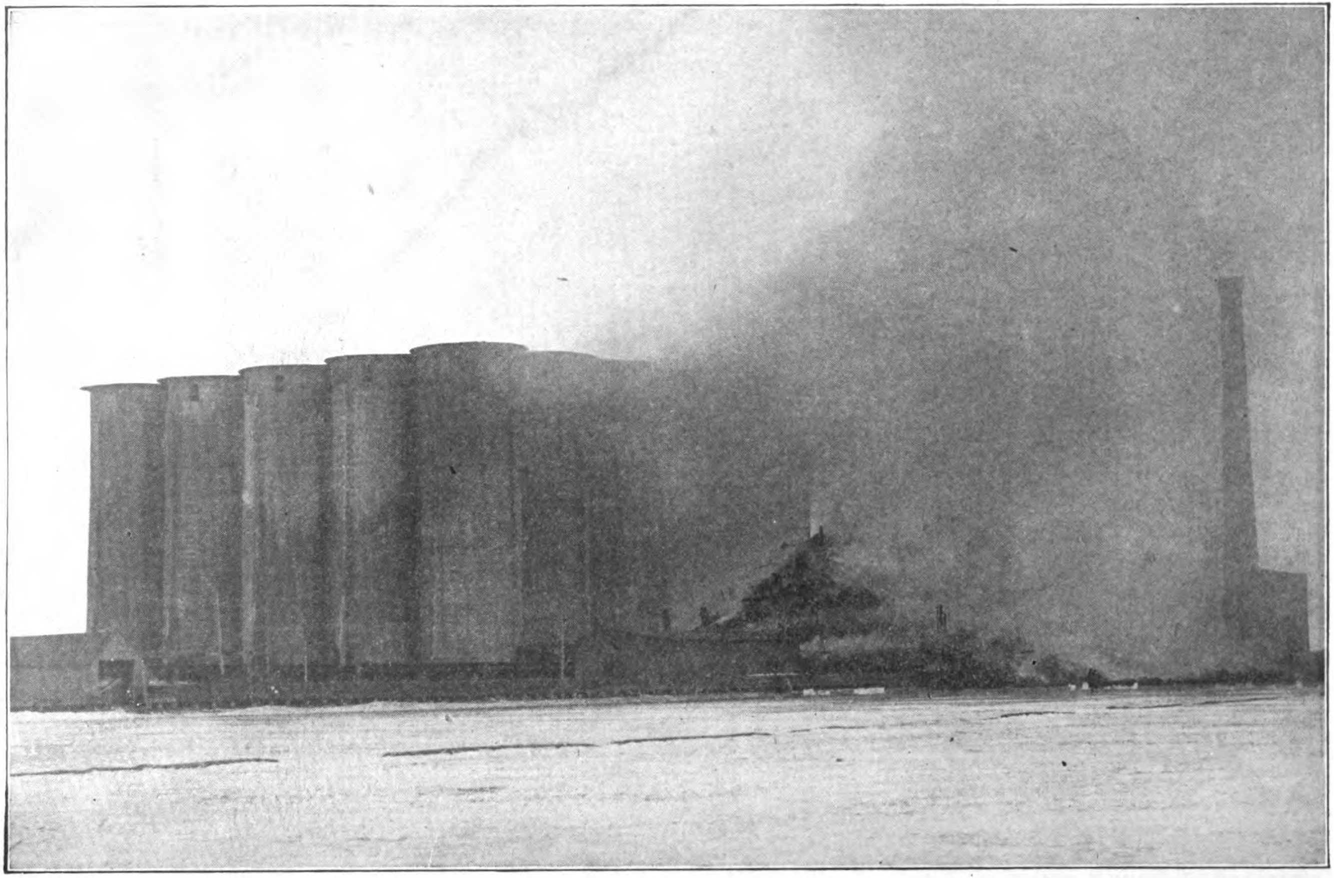

Fig. 100. View of the Peavey Elevator Plant after the Fire. Concrete Storage Tanks were Uninjured

"This concrete building is of the Roebling type, ten stories in height, of fireproof construction, having columns of structural steel protected by hollow tiling and covered with about ¾ inch of cement. The main girders are protected on the sides and beneath by plaster held in place by wire netting as are also the smaller beams supporting the floor between the girders. The floors are of cement concrete, about 6 inches thick. The windows in the south and east sides are of wire glass in metal-covered wooden frames. The enclosures at the stair and elevator towers are hollow tiling covered with plaster.

"The visible effects of the fire were: The partial destruction of the outer coating of plaster on the beams and girders, leaving netting exposed; and crumbling and dropping of plaster from inside the netting in a few places, leaving the lower sides of the steel beams partly exposed.

"Destruction of the cement coating covering the tiling at the columns, leaving the tiling exposed.

"Bending of an exposed angle iron forming the corner of the hand elevator shaft.

"Burning of the metal-covered wooden framing of the windows which fell inward on the east side.

"There was no distortion of the columns or girders which could be detected with the unaided eye. The floor leakage was very slight and appeared only at a few places at the side walls, the larger portion of the water used running down the stairway and elevator. The management states that the wire-glass windows at the tenth story formed an effective barrier to the flames which passed through the ninth-story windows in the south wall after the latter were broken out."

Dayton Motor Car Works.* A serious fire at the plant of the Dayton Motor Car Company, Dayton, Ohio, has furnished a very interesting demonstration of the efficiency of reinforced concrete as fireproof building material. No more convincing exhibit could possibly have been made than that set forth in the following notes:

"The main portion of the factory consisted of a mill-construction building of five stories and basement, adjoined by a reinforced concrete building, Fig. 101, U-shaped in plan and six stories and base-

*From an article by J. B. Gilbert, in the *Engineering Record*, March 28, 1908.

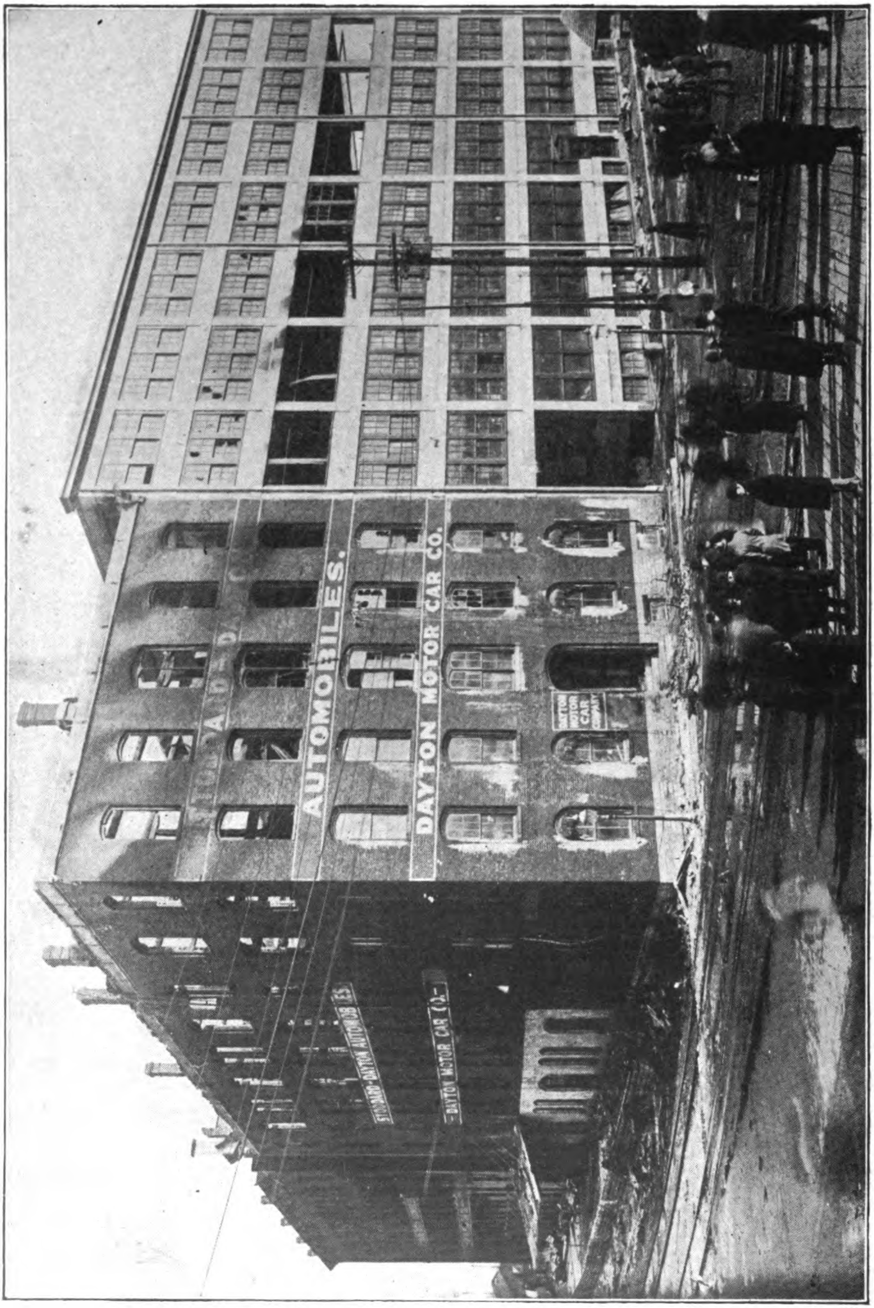

Fig. 101. Results of a Fire in Dayton Motor Car Company's Plant, Showing Reinforced Concrete Building (Kahn System) Practically Uninjured

ment in height; in fact, the two buildings were a continuous unit, as the walls of the brick building served as the boundary of the concrete building on the open side of the **U**, communication being afforded between the two buildings by means of doors on each floor.

"The concrete building was erected during the summer of 1907. At 2 A. M. Friday, Feb. 21, 1908, fire broke out from some unknown cause on the fourth floor of the new building, which floor contained the upholstering department of the factory. On this floor were large quantities of excelsior, curled hair, dry wood composing bodies of automobiles, and other inflammable materials in large quantities. The fire soon spread over the entire fourth floor of the concrete building, and, not being impeded in its progress by fire doors between the new and old building, the flames soon communicated to the old building, where the greatest damage was done. When the fire department arrived on the scene, it was apparent at a glance that the greatest destruction would be in the old building, and the chief of the department directed his men to confine their attention to it and to allow the concrete building to take care of itself. Results fully justified the confidence he placed in this type of construction. The fire burned itself out on the fourth floor of the new building, and in burning out the window frames and sash, the flames shot upward, and in some few instances burned the sash out of the windows on the fifth floor, but not enough to cause any serious damage.

"It was not long before the fire was confined to the old building, and inside of three hours, the fourth and fifth floors and roof had fallen down onto the third floor a charred mass of ruins. The fire was stopped at this point, but the building was a wreck. The walls remained standing and might be fit for a new interior, but even they bore pathetic and eloquent testimony to the inefficiency of that type of construction under stress of fire.

"The heat under the ceiling of the fourth floor of the new building was so intense that the iron pipes of the sprinkler system were bent completely out of shape, in some instances having sagged clear down to the floor. It should be stated that the automatic sprinklers were just being installed, no water having as yet been turned into the pipes and, therefore, the burnt area was unprotected from that source. Throughout the building wood plugs about 2 inches by 3 inches had been inserted in the under side of the floor panels for convenience in attaching electrical wires. The heat was so intense that these, although exposed on only one small surface, were in many cases burned completely out, leaving an empty hole in the concrete. At one place where the heat was most intense the concrete spalled off from the corners of two beams for a length of about 4 feet and a width of about 2 inches. No cracks were discoverable in the floor panels or in any beams or girders.

"One point was brought out by this fire that has a very practical bearing on the treatment of cement floors finished on a reinforced concrete slab. The concrete entering into the construction of this building was a 1 : 2 : 4 mixture, while the finished coat 1 inch in thickness was the usual mixture of one part cement to two parts sand. The finishing coat was applied as soon as possible after the main slab had been poured, but very naturally after it had taken its initial set. Where the heat was greatest the finishing coat separated from the slab and bulged up in great mounds. All of this coat throughout the burned area had to be replaced.

"Another point of interest, especially to builders in the territory adjoining Dayton, is the effect of this fire upon the aggregates used in pouring this building. The chief ingredient in point of bulk was washed river gravel, 1 inch in diameter and smaller. Its splendid resistance to this fire demonstrates beyond the shadow of doubt its fitness for this use.

"It is interesting from the manufacturers' standpoint to know that within two days after the fire the machinery was running and operations were resumed in this building. The two days mentioned were consumed in clearing away the débris incident to such a fire. The fourth floor where the most damage was done, was piled to its full capacity with salvage from the destroyed brick building, thus proving its safe condition.

"It is safe to say that if the fire doors had been in place between the old and new buildings, so as to confine the fire to the floor on which it originated, the damage would have been trifling although the sprinkler system was not in operation. The fire department could then have devoted some attention to the concrete building and checked the flames before they burned themselves out.

"In order to ascertain whether the structure had been damaged to any extent or had been weakened by the fire, it was decided to make a load test on the floor above that on which the fire originated. Before making this test a careful examination of the concrete on the under side of the beams and girders was made, and all of the concrete which had become vitiated by the heat was knocked off with a hammer. In some cases this exposed the steel reinforcement. The beams and girders which were most seriously affected in this way were selected as the ones on which the test should be made. The building was designed for a live load of 120 pounds per square foot, and the girder over which the test was made had a span of 22 feet. Equal areas on both sides of this girder were loaded so as to give a uniformly distributed load, the area covered being 352 square feet and the total load 77,250 pounds, consisting of pig iron, fly wheels, and any other available heavy material that could be obtained at the plant. This gave a uniformly distributed load of about 218 pounds to the square foot, and under this load the girder in question showed a deflection of only $\frac{3}{16}$ inch at the center of the span. Had more material been available the test would have been carried further as a matter of interest in determining how much of a load could be carried before an alarming deflection in the girder would be reached. The owners, however, on observing the amount of material that had been piled on the floor, were so thoroughly convinced of the stability of the building and of the fact that in practice it would be impossible to load their building to such an extent, that they did not feel it at all necessary to go further by obtaining materials elsewhere for the heavier loading.

"One fact of great importance was very thoroughly demonstrated, namely, that the utmost care should be used in so placing the steel that it would remain in position during the pouring of the concrete. In this building the greatest care had been exercised to secure this condition, but in spite of all precautions it was found that in some few cases the steel reinforcement was within $\frac{1}{2}$ inch of the surface. The fact that the steel remained uninjured even under this condition is a very good recommendation as to the fire-resisting qualities of concrete, but it is also a warning to use the utmost care in seeing that the steel is not misplaced during the process of pouring the concrete. In the majority of cases in this building the steel was embedded at the proper depth." * * * * * * *

Since receiving the above article the following letter from Frank B. Ramby, Chief of the Dayton Fire Department, has been obtained for publication from the Trussed Concrete Steel Company, to which it was sent:

"In reply to your favor of the 10th, in which you refer to the recent fire in the new reinforced concrete building at the Dayton Motor Car Company's plant, I would state that, this being the first fire we have had in a building of concrete construction, I am highly pleased with the results of this fire. When I had arrived on the scene, the fire had extended over the entire fourth floor. The entire contents of this floor were destroyed. The building, however, escaped with slight damage.

"Through the absence of fire doors and the inability of our department to withstand the intense heat and smoke, the fire communicated itself through an opening into the adjoining five-story brick building and was confined to the two upper floors of this structure. The biggest fight was carried on here, and the greatest loss was sustained. The lower floors, being occupied by offices and warerooms of the company, suffered greatly from water.

"The new building being of concrete construction aided us in preventing the fire from wiping out the entire plant, as we were able to concentrate practically our entire force on the old building, it requiring but a small force to subdue the fire in the new building.

"In my opinion there are a few points which this fire has proved, namely:

"*First,* that the reinforcing steel should be covered with at least 2 inches of concrete, because the fire, having penetrated the lower inch of concrete, would have injured the strength of the structure, had it not been for the rigidly attached diagonals.

"*Second,* that the finished cement surface should be put on when the floor is being laid, thereby forming a solid mass, because the finished surface was destroyed wherever the heat was intense, the slab underneath being uninjured.

"*Third,* as we were hampered greatly in handling our ladders and several of our men had a very narrow escape from being injured or possibly killed by falling sashweights, and we were compelled to force into the building all window frames that had not already fallen before we could use our ladders to advantage, I would suggest that in the construction of a building an iron pipe be embedded in the concrete for the weights to fall into, in case the window frames are destroyed by fire. If this plan were adopted in the construction of a building, it would enable the firemen to reach the fire without endangering their lives and would assist greatly in reducing the fire loss."

Thompson and Norris Building. In *Cement* for May, 1908, appears the following note regarding the serious fire in the Thompson and Norris Building of Brooklyn, New York:

"There was a fire on the seventh floor of this building which burned up the entire contents of the floor consisting of cork and paper stock. The loss was estimated at $10,000. The damage to the building consisted in the cracking of the concrete below the reinforcement on two beams, but this was repaired for a nominal sum. On the floor above were a number of printing presses which were run the next morning as usual, no sign of damage extending to that floor. The fire occurred in the afternoon and the employes quietly walked out of the building without fear of harm and the office force remained at work in the building during the fire. Some damage was done to the building by firemen breaking the wire-glass windows to let out the smoke. After failing to break holes in the floor-slab with axes, in order to let the water run off quickly, the firemen secured a piece of cold rolled shafting and using this as a battering ram, managed to punch some holes in the floor and let the water run through, damaging the stock below."

F. W. Tunnell and Company Building. In *Cement Age* for August, 1909, appears the following report of a fire in the Glue Manufacturing plant of F. W. Tunnell and Company.

"The building was erected in 1906 by Ballinger and Perrot, Architects and Engineers, Philadelphia. It is a three-story structure 104 feet by 43 feet, and is of reinforced concrete throughout. The second floor is supported on reinforced concrete columns spaced about 15 feet, and the third floor and roof have a clear span of 39 feet, supported on cross-beams 12 inches by 26 inches, the latter reinforced by eight $1\frac{1}{4}$-inch round rods. The slabs are $4\frac{1}{2}$ inches thick, reinforced with $\frac{3}{8}$-inch round rods on 6-inch centers. The floors have a 2-inch cinder concrete base over the slabs with a 1-inch cement top coat. The walls are reinforced concrete, 12 inches thick. The wall construction includes pilasters. The windows were of the metal frame and wire-glass pattern. Edison Portland cement was used.

"About this building, Fig. 102, and comprising a part of the plant, were several frame buildings. It was in one of the latter buildings that the fire took place, due, it is said, to spontaneous ignition. Thus, when the fire was in full blast the concrete structure at certain points was practically enveloped in flames. The contents of the factory made an intensely hot fire; in fact, the heat was so intense that the wire glass in the concrete building melted, this being attributed to the fact that the windows were open, thus permitting the flames to gain access to the interior, and to surround the glass. Judging from previous tests of wire glass it would probably have withstood the heat with the flames confined to one side. Wooden drying racks in the concrete building took fire and soon there was a mass of flames within and without. The buildings immediately adjoining the concrete structure were, with one exception, totally destroyed. Even a brick boiler house adjoining the concrete building, Fig. 103, was so badly damaged that it was necessary to take down the walls. The destruction of the brick structure affords an interesting comparison with the behavior of the concrete building. The building that escaped destruction owes its survival to the fact that it was protected by the concrete building, the latter proving to be an effectual barrier to the fire.

"When the fire finally subsided it was found that the concrete building was practically uninjured. That it was thoroughly tested is indicated by the fact that a wire lath and plaster ceiling suspended from the roof beams was practically destroyed. The ceiling was not intended as a protective feature, but merely to prevent the beams from deflecting or interfering with air currents forced through the room during process of manufacture.

"One end of the building was open, and through this the flames concentrated upon a concrete column which merely spalled. Shrinkage cracks here and there widened under the stress. The bottom of a concrete cantilever had also spalled, but the damage can all be repaired at slight cost by patching. The vital parts of the structure remained intact.

"The owners are so pleased with the behavior of the building

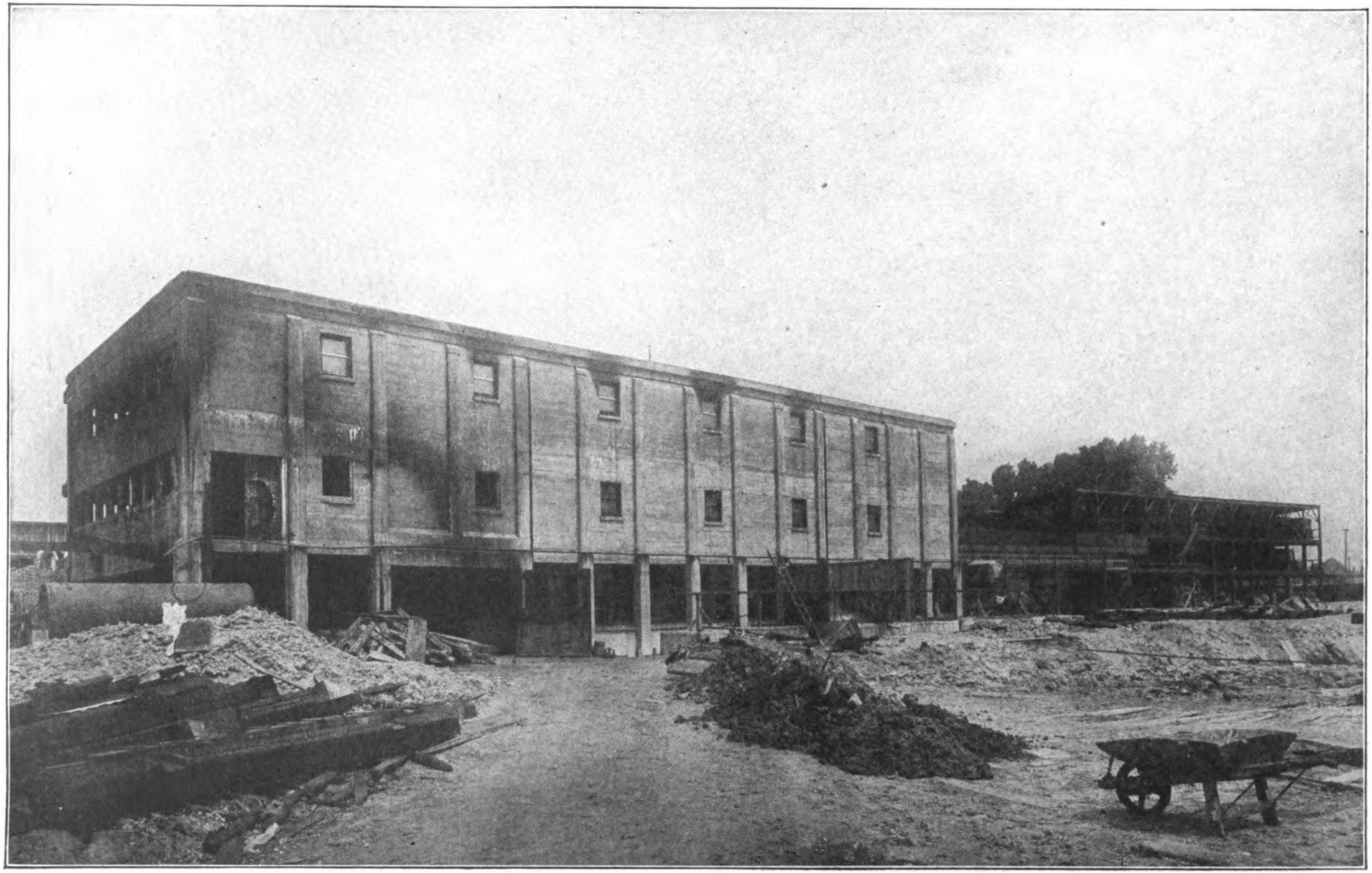

Fig. 102. Tunnell Glue Factory which Successfully Withstood Fire which Occurred in Building at the Left of Picture

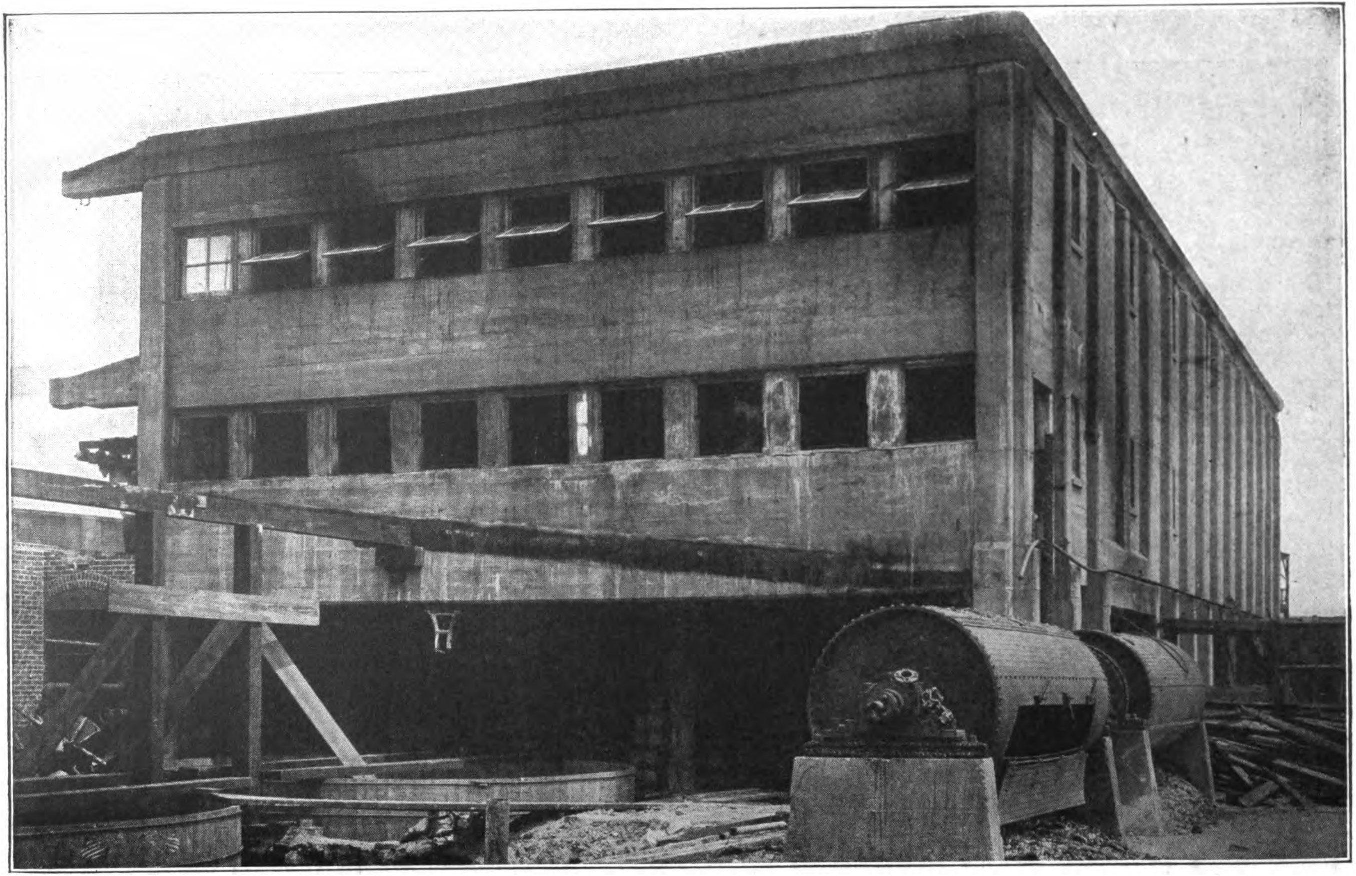

Fig. 103. Tunnell Glue Factory Showing End of Building Tested by Fire. Temperature Probably 1500° F., Sufficient to Melt the Wire-Glass Windows. Concrete Undamaged

that they promptly authorized Ballinger and Perrot to prepare plans for additional reinforced concrete buildings to replace the structure destroyed.

"No practical purpose would be served by going further into the details of this fire. It only remains to be said that the result corresponds with practical tests of other concrete buildings subjected to the same conditions. The unusual circumstance in this case was the fact that the structure was attacked from within and without, but, as stated, the slight damage can be repaired at trifling cost. So far as this building is concerned the business of the firm can proceed without interruption, and with the new buildings of reinforced concrete there will be established a plant upon which the item of insurance may be eliminated to say nothing of the satisfaction of knowing that fire cannot burn it."

Concrete Cottage at Winthrop Beach. One of the most interesting records of a fire in a concrete building where the walls rather than the floors were subjected to a fire test is reported by E. S. Larned, Consulting Engineer, Boston, in *Cement Age* for September, 1909.

"On the night of October 2, Winthrop Beach, a suburb of Boston, suffered a most disastrous fire, which in the point of time and intensity is rather notable. Two large hotels of frame construction, and seven other frame houses were destroyed, the fire occurring about 11 P. M., and in the short space of two hours, the cellar walls contained only the smoldering ruins. This property was all located on Crest Avenue, overlooking the ocean, and the character of construction and furnishings of the buildings offered no stay to the progress of the flames.

"A concrete cottage, Fig. 104, was in the course of construction, immediately adjacent to the Crest Hall Hotel, a distance of only 8 feet intervening. This concrete house was of monolithic wall construction, the first story being 10 inches thick, having a continuous air space 3 inches wide; the second story was built 8 inches thick, furred on the inside to give a 2-inch air space.

"Fig. 105, which was taken at midnight, shows the incomplete condition of the concrete building and its appearance as the fire broke through the partially completed roof. The interior construction was of lumber and at the time of the fire the floor joists and

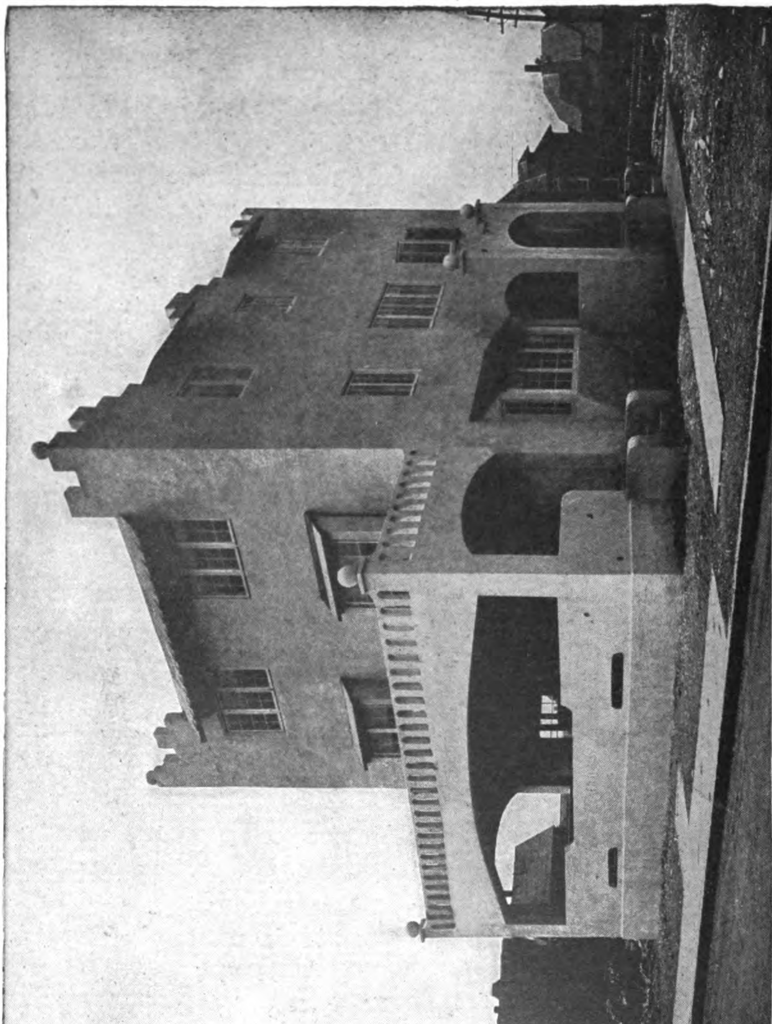

Fig. 104. Concrete Cottage at Winthrop Beach, Massachusetts

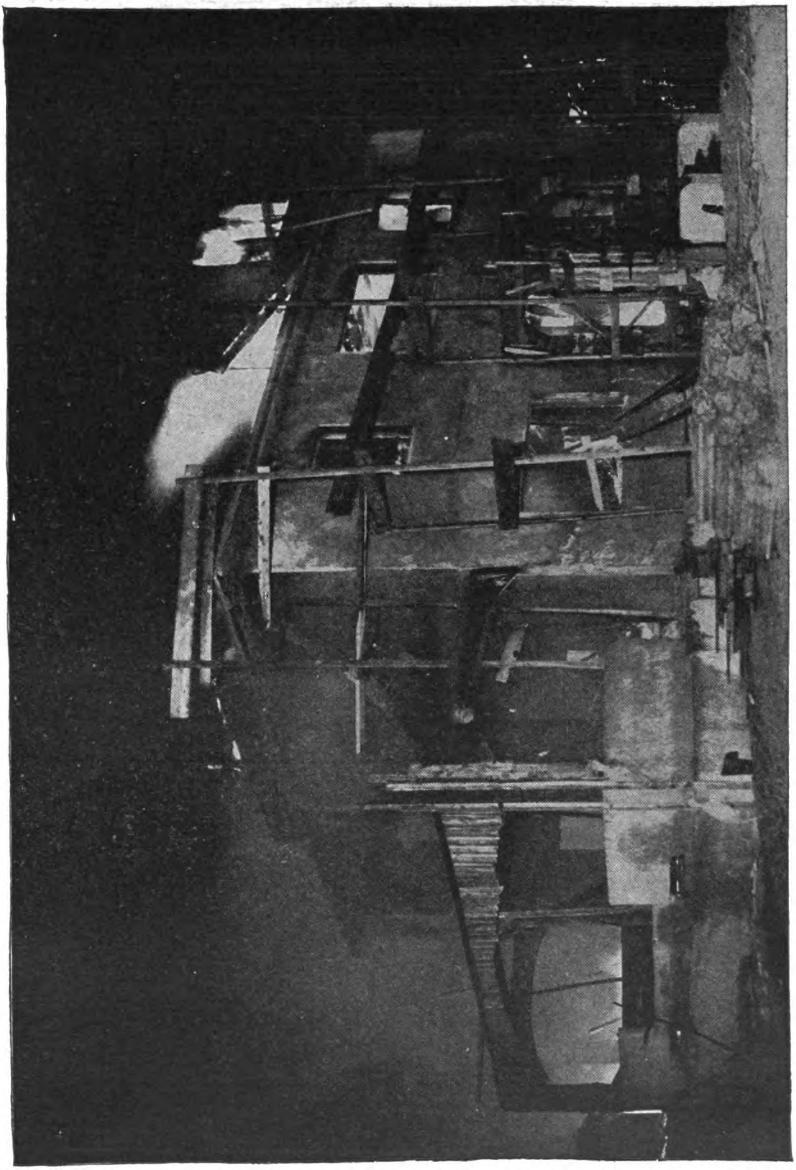

Fig. 105. Picture Taken at Midnight of Winthrop Beach Cottage During the Progress of the Fire

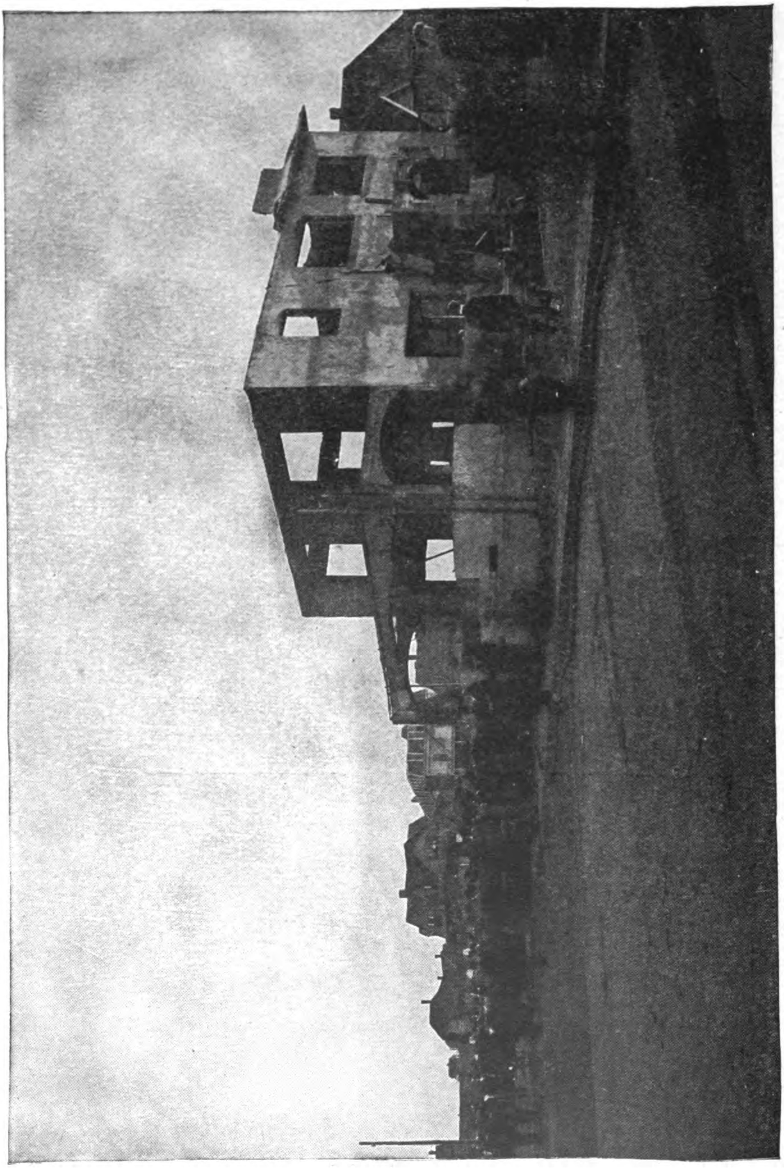

Fig. 106. Winthrop Beach Cottage After the Fire. Concrete was Undamaged and Cottage was Rebuilt with Same Walls

boarding were in place, and the roof had been covered in with 1-inch boards, upon which was to be constructed a light concrete covering reinforced with expanded metal. The window and door openings had not been closed in, so that the fire from the adjacent hotel had ready access into this incomplete building. Much of the wood trim, door and window frames and sash, were stored in the cellar of this building—fuel for the quick, hot fire.

"The concrete in the walls was of Edison Portland cement in the proportions of 1 : 3 : 6 in which beach sand and gravel were used as aggregates.

"The exterior of the building was finished with a ¾-inch coat of Portland cement mortar, and this finish was about ten days old at the time of the fire, the walls having been constructed about three weeks earlier.

"Fig. 106 shows the concrete building after the fire, and inspection by the writer three weeks later indicates that the strength of the concrete walls has not been impaired, the only injury being done to the plastering on the side of the wall immediately adjacent to the hotel which was destroyed. This plastering will be stripped off and the walls replastered, the damage being only superficial.

"As an evidence of the intensity of the heat, it is noted that granite curb stones on the opposite side of the street have crumbled and spalled off so that they will have to be relaid; the concrete steps at the rear of the cottage, within 12 feet of the hottest part of the fire, have not been damaged.

"An interesting feature in this fire is found in the fact that the fire department, realizing that the frame buildings were doomed to destruction, concentrated their efforts to protect other adjacent frame houses, and left the concrete cottage in its incomplete condition to take care of itself."

F. B. Klock Building. In *Cement Record* for December, 1909, there appears the following account of a fire in a reinforced concrete building showing the actual damage caused by the burning of 6,000 pounds of drugs:

"An interesting report was made lately by George A. Stage, Adjuster for John Naghten and Company, Chicago, on the fire loss of the reinforced concrete factory building of F. B. Klock, South Elgin, Illinois.

"The adjuster contended that the concrete floors and ceiling were not damaged sufficiently to be torn down, but the owner claimed that the concrete had been weakened by the intense heat, about 6,000 pounds of drugs having burned. It was decided to test the building by putting a weight of 400 pounds to the square foot on the panels, which were to be held defective if they deflected more than $\frac{3}{16}$ inch, that being the original test made by the architects when the building was turned over to the owners. Tests were made of eight panels involved in the fire, all of them showing more than $\frac{3}{16}$-inch deflection with 250 pounds to the square foot. When the same weight was applied to other panels in the building not affected by the fire, the deflection was less than $\frac{1}{10}$ inch. In consequence a total loss was allowed on six panels and a compromise on two. The adjuster held that had the building been of any other construction than concrete it would have been totally destroyed owing to the tremendous heat engendered by the burning drugs. The expansion of the reinforcing steel under the intense heat is believed to account for the weakening of the concrete.

"In his report the adjuster states the following: 'In conclusion I wish to add that the test which was made demonstrates to us the practicability of concrete construction. The tremendous heat created by the burning of 6,000 pounds of drugs would have meant a total loss of the building had it been of any other construction.' "

Rubber Reclaiming Manufacturing Plant. In the *National Fire Protection Association Quarterly* of April, 1910, appears the following record of a fire in the Rubber Reclaiming Manufacturing plant:

"The fire started in the main room on the upper floor of Mill 'B' and was first seen in the drying screens where the reclaiming rubber, ground to a fine pulp, was spread and subjected to a draft of air heated by being forced through steam pipe coils by fans. The fire was probably caused by an overheated journal in this rapidly revolving fan system. The watchman's clock showed that he had visited this room within twenty minutes prior to the discovery of the blaze by the mill employes who were working on the ground floor of the building. The private fire department was at once called into action and in a short time five streams of water were in service.

"The building was constructed of reinforced concrete with 8-inch walls, 16-inch piers, and 4-inch floors on heavy concrete columns and stringers. The roof was composition laid on several thicknesses of boards, trusses braced with iron rods. The only ignitible materials were the stock, roof, one frame partition, and the wooden framework of the drying apparatus. The stock was particularly inflammable and evidently burned fiercely, for, despite the water thrown upon it, the heat was sufficient to cause the iron rods to bend

Fig. 107. Effects of a Fire in the Rubber Reclaiming Manufacturing Plant

under the weight above them and tear down the concrete walls into which they were fastened, thus demolishing all of Mill 'B' above the floor line of the second floor, Fig. 107.

"The damage to the property on the lower floor was almost entirely by water, though some little fire dropped down from above.

"Separating Mills 'B' and 'C' was a reinforced concrete wall which did not go through the roof. Through this wall was a large opening on each floor protected by a single door on the Mill 'B' side; that on the second story was torn away in some manner, probably by the falling roof, and the fire spread into Mill 'C', although the damage in it was confined principally to the crude rubber which was hanging up for air drying. There was considerable water on the ground floor of Mill 'C'."

McCray, Morrison and Company Elevator. In *Rock Products* for May 22, 1910, appears the following description of the destruction of a 100,000-bushel grain elevator, which partially surrounded a reinforced concrete grain drier so that the latter structure was subjected to a very severe fire test:

"Concrete construction was put to a crucial test in the burning of the 100,000-bushel elevator of McCray, Morrison and Company, at Kentland, Indiana, last month, says the *Grain Dealers' Journal.* At the time of the fire everything was very dry, and the buildings were so quickly enveloped in flames the workmen scarcely had time to escape with their lives.

"Figs. 108 and 109, showing the plant before and after the fire, tell the story clearly and accurately. In an L formed by the different buildings a reinforced concrete grain drier had been erected and enclosed by a frame ironclad covering. This building was 10 feet from the grain elevator building on the side and 16 feet distant on the end, which was connected to the elevator with wood conveyor boxes.

"The plant contained approximately 450,000 feet of lumber and 50,000 bushels of grain, which were consumed in a few hours, leaving nothing but the concrete drier standing plumb, surrounded by a smoldering mass of débris. The drier housing was burned away; the metal fans and steam pipes were red hot and warped; the brass grease cups on the fan bearings were melted and the iron doors warped. But the concrete work remained intact with little damage, notwithstanding that it contained about 700 bushels of corn which was reduced to ashes during the fire. The drier supported its own garner and 12,000 pounds of steam pipe, yet not one of its supports failed.

"In no previous grain elevator fire has concrete been put to such a severe test, and in no case has it passed through a fire with more gratifying results to owners and builder."

Pacific Coast Borax Company's Building. In *Cement* for September, 1910, a reference is made to one of the earliest fires in reinforced concrete buildings, namely in the Pacific Coast Borax Company's building at Bayonne, New Jersey.

"In this case a four-story building, entirely of reinforced concrete construction, except that the roof was of wood, was quite thoroughly burned out, in the upper two stories, by fire that originated in an adjacent one-story section. The wooden roof was entirely burned off and all of the inflammable contents of the third and fourth floors were burned, with the result that a very hot fire, of perhaps an hour's duration, tested the concrete walls and floors of these rooms. Very little damage was done to the concrete, and I understand the necessary repairs were made at comparatively

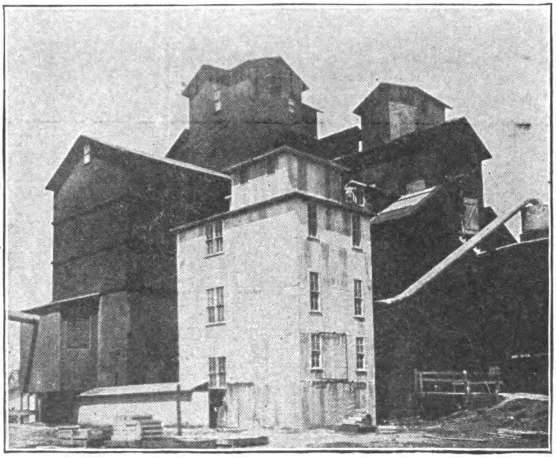

Fig. 108. McCray, Morrison and Company's Elevator and Drier Before the Fire

insignificant cost. At the same time the strength of the building was demonstrated by the fact that heavy loads, falling from the roof to the floor of the top story, did not cause any serious damage."

N. F. P. A. Report. In the report of the Committee on concrete and reinforced concrete building construction presented at the Chicago meeting in May, 1908, of the National Fire Protection Association by Edward T. Cairns, Chairman, reference was made to the fire in the Huyler Candy Factory and in the Dayton Motor Car Company's plant, descriptions of which have been given above. Mr. Cairns also gave the following notes regarding other fires:

Concrete Buildings. "On May 27, 1907, a fire occurred in Merritt Brothers' Factory at Camden, New Jersey, which in a building of ordinary construction would doubtless have resulted disastrously, but proved, under the circumstances, to be chiefly a demonstration of the fire-resistive quality of the building.

"The building in which this fire occurred is a five-story structure, occupied for the manufacture of metal clothes-closets for factories. The columns, beams, floors, and roof are of heavy type reinforced concrete, the mixture being 1 : 2½ : 5 small size crushed trap rock. The walls are brick carried on a concrete frame. The fifth story was occupied for painting and drying. In the corner of the room were two wooden gas-heated drying ovens approximately 7×10×8

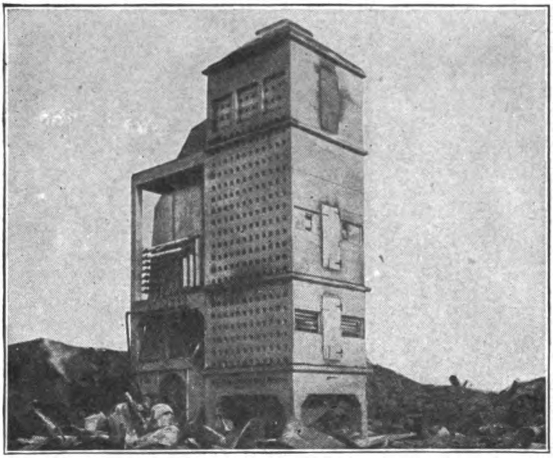

Fig. 109. Same After the Fire. Reinforced Concrete Drier the Only Building Standing

feet and along the side of the room next to this were a number of smaller ovens, all of metal construction. These two wooden ovens had been filled with freshly painted metal to be dried. An employe endeavored to light the gas under the oven and he either dropped his torch or the burners failed to ignite properly so that the paint and the drip pans close by caught fire and the flames promptly extended into the oven.

"The fire, which lasted from one-half to three-fourths of an hour, practically burned up the wooden ovens and some of the other light inflammable materials close by. The flames did not extend very far into the room, however, though there was enough heat to melt out the soldered metal frames of the wire-glass monitors on the roof a little to one side of the ovens, and to melt the links on two fire doors, 40 to 50 feet away. The concrete columns and ceiling in the immediate vicinity of the fire showed some cracks but no material injury; absolutely no repairs of any sort were made to the concrete after the fire, the only repairs being those made to the above-mentioned wire-glass window frames.

"On May 30, 1907, a fire destroyed the factory of the Waverly Paper Box Board Company, Waverly, New Jersey, and afforded a test of concrete, the entire plant having plain 12-inch solid-concrete walls one story high. The floors were also of concrete, but the roof was wood and was entirely consumed with the combustible contents of the buildings. The walls seem to have been of fairly good gravel concrete and suffered some damage from the cracking and the dehydration of the cement at the surface, but as a whole they may be said to have resisted this fire about as well as brick would have done, and have since been used in the rebuilding of the factory.

Concrete Blocks. "There have probably been several fires in buildings of concrete block construction, but only three, which seem to warrant special mention, have been reported to the Committee.

"One occurred in Nashville, Tennessee, in the summer of 1907, and was fully reported in the *Quarterly* of January, 1908 (page 178). This was a four-story building 50 feet by 170 feet with walls of two-piece concrete blocks and a wooden-joisted interior, occupied throughout by a retail furniture store. The top story and the attic were completely burned out but the damage to concrete block walls was nominal and easily repaired. The test could not be termed severe, but under the circumstances the blocks made a creditable showing.

"The fire apparently started in the attic in the vicinity of the elevator sheaves and spread throughout this space, burning off the roof of the suspended ceiling and also burning out most of the contents of the top story; it did not, however, entirely burn the floor, nor did it extend to any of the stories below.

"It is quite apparent that the heat in the top story was severe for a limited period, especially against the concrete blocks forming the top of the walls above the suspended ceiling. The result was the spalling and chipping of window lintels and sills to a considerable extent and the destruction of galvanized iron cornice, but so far as could be ascertained there were no serious fractures in the walls or their individual blocks.

"As a precautionary measure, the Building Department insisted upon the erection of a number of reinforcing pilasters around the inside of the building, and after this was done the roof and suspended ceiling were replaced in practically the same manner as before. The sills and lintels of the windows were patched up with cement at the point where the worst damage occurred, and as the building stands today it shows hardly any trace of the fire.

"The second fire occurred December 9, 1907, at Anderson, Indiana, in a three-story building just completed, but not yet occupied. The house was fitted up for an Old People's Home, had ordinary single-piece hollow concrete block walls, wooden interior, and was fairly good size, containing forty living rooms, office, dining rooms, etc. The entire interior was burned out, but the walls stood with very little damage, except at the top and around windows; these walls have been used in the reconstruction.

"The third fire occurred at Murfreesboro, Tennessee, April 29, 1908, in a basement and two-story building 60 feet by 115 feet, occupied in basement and first story for storage of hay, grain, feed, cotton, and hardware. Walls were 10 inches thick, made of single-piece hollow-concrete blocks; floors and roof were of ordinary joist construction. The fire started in the first story and burned from 9:30 P. M. till midnight and the effect is well described by the report of the Tennessee Inspection Bureau as follows:

"The blocks were of a heavy type, and the aggregate used was a good quality of small crushed stone—very little sand being used—but the cement was of poor quality and insufficient quantity. A number of the blocks examined after the fire show that there was no uniformity of manufacture. The temperature of the fire seems to have been very moderate; in fact, several lines of interior girders were burned only to a depth of about 4 inches, and sacked cottonseed, etc., stored in the basement, was not totally destroyed. The temperature was also evenly distributed, though concrete blocks in different portions of the walls did not stand the fire alike, in some cases the disintegration being excessive or total—notably the second story of the front wall—while in other instances the blocks remained in a fair state of preservation, though with no mechanical strength and badly chipped and spalled.

"The effect of water on the heated blocks and wall is shown by the blocks which fell from the building; these blocks absorbed water greatly, being found damp thirty-six hours after the fire had been extinguished, and crumbled when dropped upon one another, being no stronger than unslaked lime.

"Unequal expansion between the outer and inner shells of blocks is clearly demonstrated by the rear wall where the bond between the outer and inner shells of blocks is cracked continuously, almost the entire length of the remaining wall.

"Imperfect mortar and mortar joints were found in all portions of walls remaining, the horizontal bond being only on the outer edges of outer and inner shells. This same defect is noted in vertical joints. The quality of mortar used was very poor and stood the fire even worse than the blocks themselves. In a number of cases it can be scratched away with a match, like sand.

"All the blocks examined were very porous, no means at all having been taken to prevent small voids which prevailed throughout.

"All walls above the first floor fell, the rear and front walls being completely down, with the exception of several remaining courses of blocks of the rear wall. This rear wall fell first, carrying fire into a frame L of a livery stable, No. 223 West Main Street. This was followed by the west wall, which carried fire into the frame, iron-clad blacksmith shop, No. 221 West Main Street, completely consuming it. It should be noted that the only weight carried at all by the walls was the dead weight of the second floor and the roof, the second floor (skating rink), at the time of the fire, being unoccupied. Beyond considerable chipping and a small amount of spalling, the limestone foundation which formed the basement wall was not badly injured, and with repairs might be used again. The total damage to the Overall Building, and contents, is estimated at $10,000, with insurance of $2,000 on building and $4,000 on contents.

"*Conclusions:* The concrete blocks, though heavy, were manufactured of inferior materials, under light pressure, and with no uniformity whatever. The combined effect of heat and water completely destroyed all mechanical strength. They were very porous, absorbed a great deal of water—no provision having been made to fill small voids. The blocks subjected to the greatest heat disintegrated badly; in falling they broke into small pieces, being no harder than unslaked lime. The mortar joints were imperfect and the quality of mortar used was poor. In fact, even if the blocks had been good, it is to be doubted whether the wall would have stood, the heat evidently releasing all bond at mortar joints. The fire demonstrated the unreliability of this class of construction.

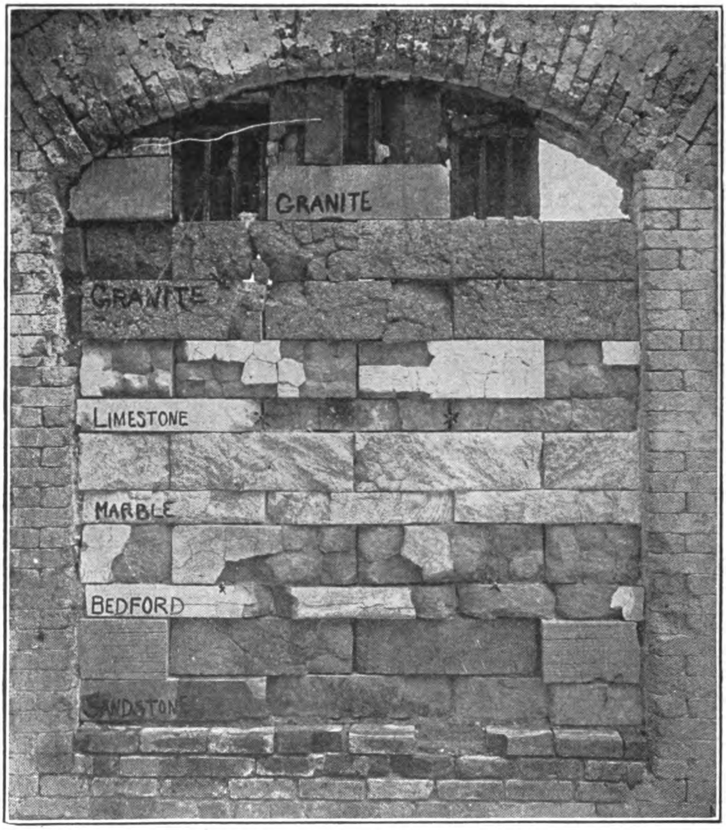

Fig. 110. Appearance After Exposure to Fire and Water of Test Panel of Miscellaneous Building Materials

The blocks and mortar joints may be good or bad—though usually bad—and in order to obtain correct information on specific cases, a fire is necessary and the information obtained expensive.

"This was undoubtedly a long hot fire and furnished a more severe test of the blocks than the other two fires mentioned above and seems to justify the opinion of the Committee expressed in last year's report that 'well made blocks are suitable for small buildings, where no high temperatures or long continued fires are to be expected, but the hollow form in which they are made abso-

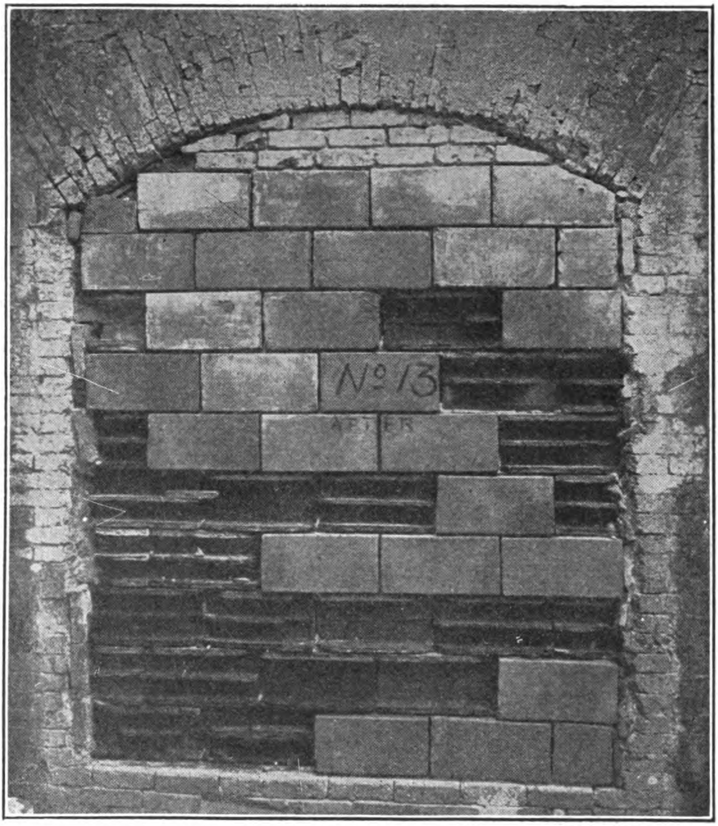

Fig. 111. Appearance of Test Panel of Hollow Tile After Exposure

lutely precludes their being classed as highly fire-resistive or suitable for fire walls, or for any buildings which may be subjected to severe fire.' "

LABORATORY TESTS

The laboratory tests to determine the fire-resisting qualities of various building materials made by the United States Geological Survey under the direction of Richard L. Humphrey at the furnace of the Underwriters' Laboratories in Chicago are described in full in bulletin No. 370 of the United States Geological Survey published in 1909, and any one desiring to familiarize himself with the results of these very elaborate tests should send to Washington for a copy of this bulletin. The author has selected from this report the de-

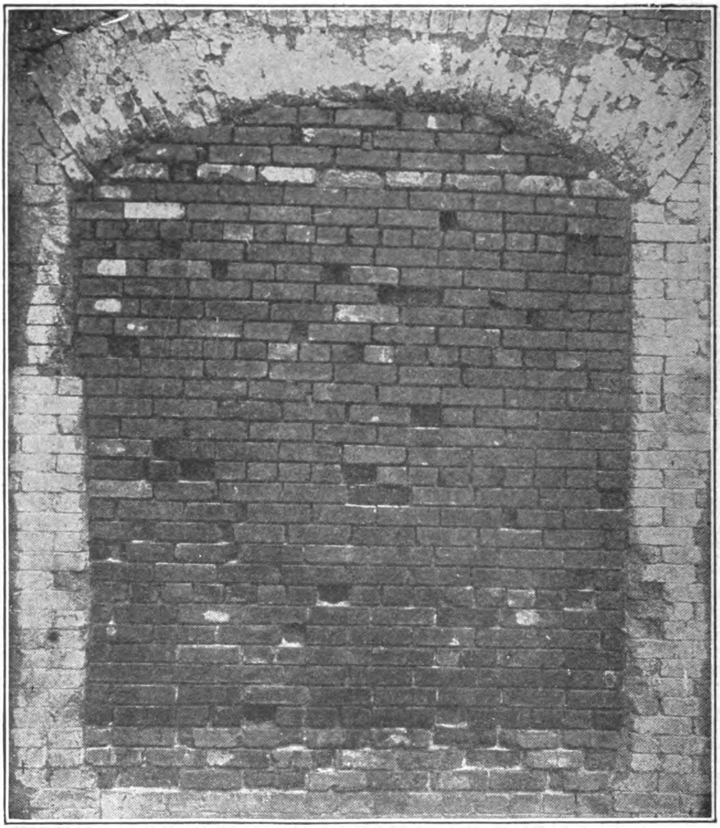

Fig. 112. Appearance of Test Panel of Brick After Exposure

scription of the tests on the four panels of concrete and a few panels of other material. There were tested altogether thirty panels of different kinds of building materials, including stone of various kinds, Fig. 110; tile, Fig. 111; brick, Fig. 112; hollow concrete blocks; and solid concrete, the latter being parts of reinforced concrete beams

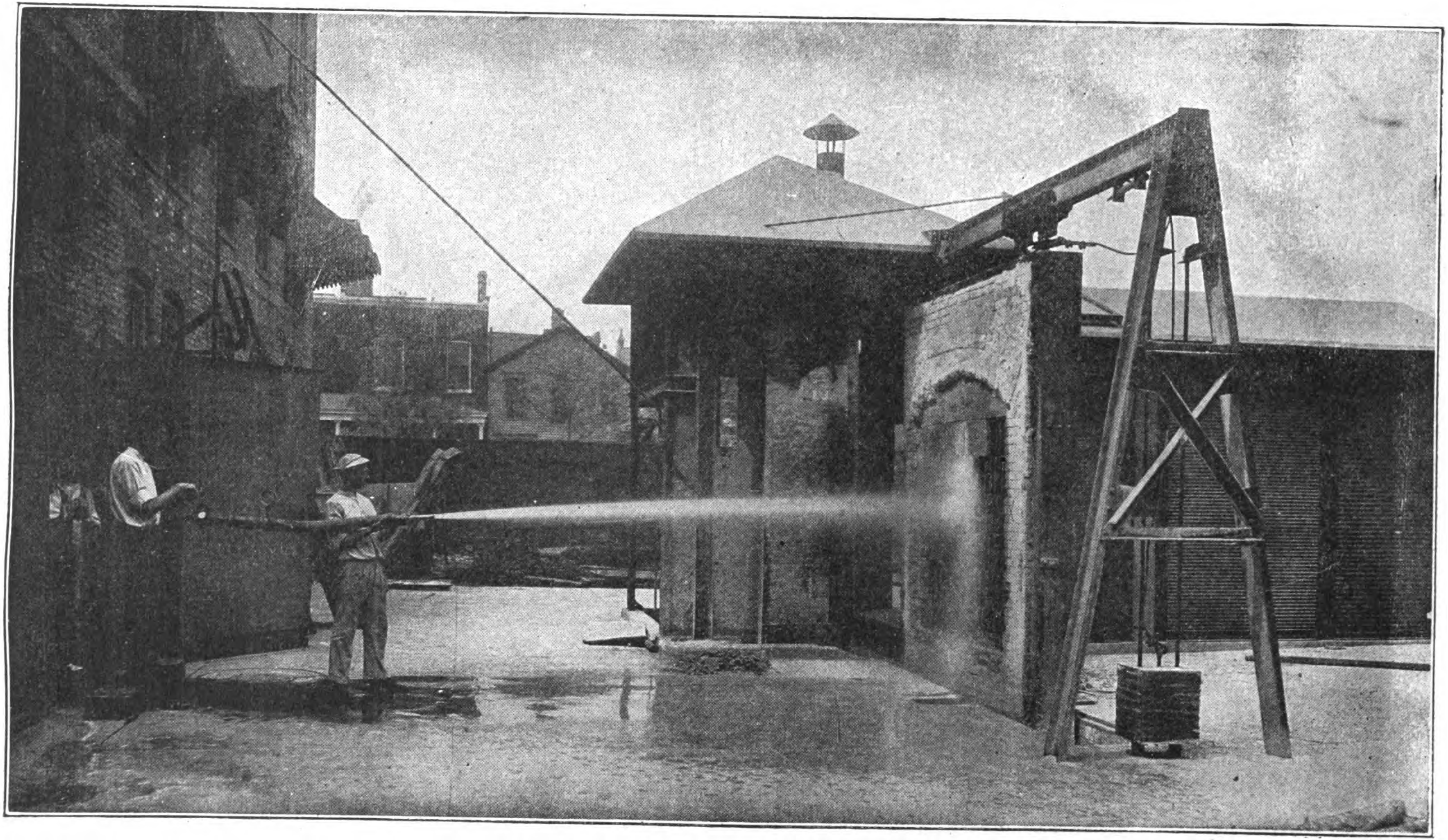

Fig. 113. View Showing Method of Conducting Government Tests on Fireproof Building Materials
After subjecting the panel to a prolonged fire test in the oven, it is rolled out and quenched with water.

tested at the Geological Survey Laboratory at St. Louis. The form of oven and manner of handling the panels are shown in Fig. 113.

Panel 17. *Materials.* "Panel 17, Fig. 114, consisted of four kinds of concrete, as follows: A 1 : 2 : 4 limestone, crushed to pass a $\frac{3}{4}$-inch screen and be retained on a $\frac{1}{4}$-inch screen; a 1 : 2 : 4 cinder, containing 24.5 per cent of combustible material (these cinders were screened to pass a $1\frac{1}{2}$-inch screen); a 1 : 2 : 4 granite, crushed

Fig. 114. Appearance after Test of Panel Consisting of Different Kinds of Concrete

to pass a $\frac{3}{4}$-inch screen and remain on a $\frac{1}{4}$-inch screen; and a 1 : 2 : 4 gravel, screened to pass a $\frac{3}{4}$-inch screen and remain on a $\frac{1}{4}$-inch screen.

"The sand and cement mixed with the above coarse aggregates were Meramec River sand and 'typical Portland' cement. The specimens fired were sections of plain beams previously tested in the Government's structural-materials testing laboratories at St. Louis. They measured 8×11 inches in cross-section and varied in length from 18 to 36 inches. These test pieces were laid in fire clay on their 8-inch side, thus exposing the 11-inch face to the fire. This arrangement permitted a section 22 inches high by 6 feet long of each material, except the limestone concrete, to be exposed to the fire in the same panel. Only one piece of the limestone concrete, about 20 inches long, was tested, as that was all of this character of concrete which could be obtained at the time the shipment was made from St. Louis.

Test. "The firing was started at 10:52 A. M. June 7, 1907, and continued for 2 hours and 3 minutes, after which the panel was quenched for 5 minutes with water. The temperature of the water was 52° F.

"At the start of the test the back of the panel was wet, owing to rain the night previous. The burners started with a fairly uniform temperature and under good control; the top was not as hot, however, as the lower part of the panel. In 25 minutes a slight pitting was noticed on all four kinds of concrete and small pieces, about ¼ inch deep and 1 inch in area, fell out from the faces. The cinder concrete developed bright red spots, from which small flames issued. These spots covered the greater part of the surface of the cinder concrete and were about 8 to 10 inches apart. At 45 minutes steam was noticed passing through the joints on the back of the wall. At 65 minutes the cinder concrete was quite badly pitted, though of a uniform color, the entire surface having attained the same color as the bright red spots before mentioned. A number of small bulges projected out from the wall about ⅛ to ¼ inch. Pits developed as these bulging portions fell away. The limestone and gravel concrete were pitted all over to a depth of ¼ to ½ inch.

"The temperatures of the furnace observed during the two-hour test were from 1,300° to 1,650° F.

Results. "On the application of water, portions of the surface of all four varieties of concrete washed away. The limestone washed away from ¼ to ½ inch, but the remaining surface was very smooth and the exposed stones showed the effect of calcination. The surrounding concrete, however, was apparently hard, free from cracks, and showed no sign of discoloration or calcination. The surface had very much the appearance of concrete which had been vigorously brushed while green.

"The stone was discolored to a depth of about 1 inch. Back of this the stone did not show any signs of heat treatment. The material on the surface had a very dead sound when tapped gently with the hammer, but on the back side it had the usual metallic ring.

"In the case of the gravel, where the mortar portion of the concrete was rather deep, the surface was still intact but the greater portion of the surface was pitted and washed away to an average depth of ½ inch. The surface was very rough and the exposed pieces of gravel were dark brown and very easily broken under the hammer. In several cases they were split and parts of the stone could be pulled out with the fingers. The particles of gravel were discolored in the concrete to a depth of 4 inches. The mortar in this layer was apparently normal, and appeared as hard as that of the unaffected product. It was but slightly cracked and only on the surface. Throughout all the pieces vertical cracks running back from the fired side were observed; they were from about 4 to 10 inches apart and extended back from the face about 2 to 4 inches. They were nearly straight in direction and could be found on both the bottom and the top of each beam. The face of the portion in which the gravel was discolored had a very deep sound when tapped with a hammer, while the back had a good metallic ring.

"In the case of the granite there was a considerable portion from which the mortar surface had not been washed away. The remaining surfaces were washed away about ¼ to ¾ inch. The exposed pieces of stone were slightly discolored, being lighter than the unaffected material, but in most cases they were hard and broke a little more easily than the unheated ones. The mortar was soft and crumbled about 1½ inches. For about 3 inches in from the face the mortar had turned a light straw color, but was quite hard. For about 6 inches from the face the concrete had a whitish tinge, which indicated that the free moisture had been driven entirely out. This whitish layer was apparently as hard as the layer on the back. To a depth of about 2 inches the pieces of stone had a rather cloudy look.

"Vertical cracks ran directly back from the face on both the top and the bottom of the beam, being from 2 to 6 inches apart and extending back from the face 4 inches. By tapping, the beams could be broken across these cracks. The face had a very hard sound when tapped with the hammer; the back had the usual metallic ring.

"In the case of the cinder a part of the face was still intact after the application of water. However, it is very likely that the upper

Fig. 115. Appearance After Test of Panel Containing Granite-Concrete Beams

left-hand corner was more or less protected from the intense heat to which the remainder of the panel was subjected. On the other parts of the cinder concrete the spalling from the fire and water was from $\frac{3}{4}$ to $1\frac{1}{4}$ inches deep. The surface was very rough and very badly pitted, although no cracks could be observed. For about one inch the concrete was black and looked very spongy, because the particles of combustible material had been entirely burned out. In a layer about ½ to ¾ inch thick directly behind this spongy layer, the concrete was black and looked as if it had been badly smoked. The combustible material in the center of this layer was caked. Back of this layer was a strip 3 to 3¼ inches wide showing no discoloration, but the mortar was whiter than the normal concrete, indicating that the uncombined water had been driven away. The remainder of the beam was apparently normal.

"Vertical cracks running back from the fired face were found in only two or three cases and extended back only 2 to 4 inches. The surface had a very dead sound and could be easily crumbled, while the back of the beam was unaffected and had the usual metallic sound.

Panel 18. *Material.* "Panel 18, Fig. 115, was made up of short lengths of plain granite-concrete beams 8 to 11 inches in cross-section and in lengths varying from 18 inches to 2½ feet. The concrete was a 1 : 2 : 4 mixture of 'typical Portland' cement, Meramec River sand, and Missouri red granite. The stone was screened to pass a ¾-inch screen and be retained on a ¼-inch screen. The panel was laid up in fire clay with broken joints. The specimens were laid on their 8-inch side, thus exposing the 11-inch face to the fire.

Test. "The test occurred on June 10, 1907, and firing continued for 2 hours and ½ minute. After firing the face of the panel was quenched with water at 51° F. for 5 minutes.

"In 15 minutes snapping was noted, which continued for about 5 minutes. At 25 minutes hot water was forced back through the joints and washed off the fire clay, which held the back wall thermometers in place. This water was considerably warmer than the back wall surface, consequently the thermometers there attached showed unduly high temperatures. At 40 minutes the top of the panel began to dry out, the bottom portion still remaining wet with the water which leaked through the joints. At 63 minutes a slight spalling was observed in several places, principally at the top of the wall. At 75 minutes the back wall face of the panel had entirely dried out, but steam came through the joints on the top. During the remainder of the time no further change was noted.

"The temperatures of the furnace observed during the two-hour test were from 1,300° to 1,700° F.

Results. "After quenching with water it was found that some portions of the surface of the concrete had spalled and had been washed away, while in other places the surface was nearly all intact and the mortar still adhered; but it was cracked and crumbled

Fig. 116. Appearance After Test of Panel Containing Gravel-Concrete Beams

easily in the fingers. The exposed surfaces of the stone were found to be of a cloudy whitish color and quite hard, although more easily broken than the unchanged stone. The stone had whitened to a depth of about 1 inch and the mortar to about 3½ inches.

"Vertical cracks running back from the fired face occurred about 4 to 6 inches apart, and extended back from the face about

4 inches. By tapping with a hammer, the beam could be broken where these cracks occurred. The surface had a very dead sound when tapped with the hammer, but the back was apparently normal.

Panel 19. *Material.* "Panel 19, Fig. 116, was composed of similar sized sections of gravel-concrete beams, laid as described for panel 18. The mixture and consistency were the same as in panel 18, being 1:2:4 medium consistency. The gravel passed a $\frac{3}{4}$-inch screen and was retained on a $\frac{1}{4}$-inch screen, and was of the Meramec Flint variety.

Test. "The test took place on June 11, 1907, at 2:25 P.M., and continued for 2 hours 3 minutes, followed by quenching with water at 53° F. for 5 minutes. At the outset the temperature at the top of the panel seemed higher than that at the bottom.

"In 16 minutes water came through the joints on the back of the wall and ran down, washing away the fire clay holding the thermometer in place. Up to 25 minutes no snapping had taken place. At 45 minutes the greater part of the surface of the concrete had spalled and pitted in small spots. These pits exposed small stones which had probably cracked and expanded sufficiently to force the mortar away from the face. At 80 minutes the pitting and cracking away of the small portions of the surface was very general over the lower and left-hand side of the panel. No further change was noted and the surface of the panel seemed to resist any further pitting.

"The temperatures of the furnace observed during the two-hour test were from 1,500° to 1,900° F.

Results. "Fig. 116 shows the face of the panel after the test. On the application of water the surface washed away on the lower and left side of the panel, while on the upper and right side of the panel the surface was less severely affected. Particles of gravel were discolored to a depth of $2\frac{1}{2}$ to 3 inches, turning a dark reddish-brown, while the mortar surrounding them remained about normal. Many gravel stones on the surface had split, but were apparently as hard as the sound ones. Vertical cracks from 2 to 4 inches ran back from the face to a distance of about 3 inches.. These cracks could be opened up by tapping, and the layer containing the discolored gravel could be cracked off from the surface of the beam with a hammer. The back portions of the beams were not affected and had a solid metallic ring, while the fired side sounded dead when struck with a hammer. Where the mortar had not been washed away the surface was covered with fine hair cracks and the material could be crumbled in the fingers. The

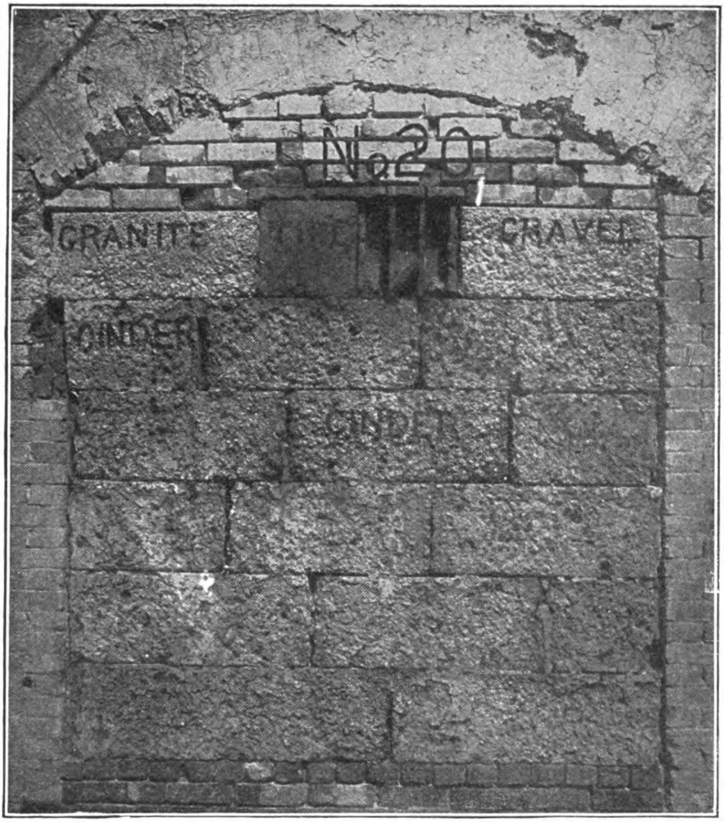

Fig. 117. Appearance After Test of Panel Containing Cinder-Concrete Beams

gravel under this coating of mortar was not cracked but was somewhat discolored.

Panel 20. *Material.* "Panel 20, Fig. 117, was made up of 1½-inch to 2½-foot lengths of cinder concrete beams, 8 by 11 inches in section, laid on the 8-inch face. The concrete was of 'typical Portland' cement, Meramec River sand, and soft coal cinders, containing 24.5

per cent of combustible material. The proportions were 1:2:4 by volume. The cinders were screened to pass a 1½-inch screen and be retained on a ¼-inch screen. The top row in the panel was composed of granite, gravel, and terra-cotta tile and was put in merely to fill up the space due to a shortage of the cinder specimens.

Test. "The panel was fired at 11:54 A.M., June 17, 1907, for 2 hours and 2¾ minutes, and was cooled by quenching with water 57° F. for 5 minutes.

"In 7 minutes the concrete snapped quite badly and one or two small explosions forced off small portions of the surface of the beams. No. 7 was more exposed than usual on account of the fire clay mounting being cracked off by a piece of the surface of the cinder concrete which blew across the furnace. At 18 minutes all of the cinder-concrete surface had begun to pit and pieces about 1 inch in area and ⅛ to ¼ inch in depth fell out. A piece on the second row from the bottom, about 6 inches square and ½ inch in depth, was forced off with considerable violence,. exposing several pieces of unburned coal. This was followed by several small explosions, and a piece of the surface about 8 inches square and ½ inch thick just adjoining the above-mentioned piece, came off. Small bright red spots from which flames issued were distributed over the surface. At 30 minutes the burners became more or less clogged from the small pieces of concrete which had fallen into them. This somewhat impaired the control of the furnace. At 40 minutes the spalling became general over the surface and many small pieces of concrete continued to fall from the panel. The color became bright red and the small spots were no longer visible.

"The temperatures of the furnace observed during the two-hour test were from 1,400° to 1,700° F.

Results. "On removal of the door it was found that the greater part of the surface of the cinder concrete had cracked off; during the application of water a considerable portion of the surface was washed away, apparently to about the same depth (½ inch). A very small portion of the face of each beam was still intact, but this portion was porous and crumbled easily in the hand. The surface was rough and the concrete spongy and black to a depth of about 1 inch. The mortar in this layer was easily crumbled in the fingers. A layer 3 to 4 inches thick back of this was discolored, being turned almost black, and the particles of combustible material were practically turned to coke. The mortar in this layer was apparently hard. The remainder of the beam was about normal.

"Fig. 117 shows the face of the panel after testing. A few vertical cracks running back from the face of the beams were not very regular and did not open up readily when tapped rather hard with a hammer. The face of the concrete crumbled when tapped, while the back gave a good sound metallic ring. The affected portion—that is, a layer about 2½ inches thick—could be separated from the unaltered portion by tapping on the edges of the piece."

Further Tests. In a paper presented before the National Fire Protection Association by Leonard C. Wason, President Aberthaw Construction Company, on *Reinforced Concrete as a Fireproof Building Material,* the writer states:

"The maximum depth of pitting observed by the writer in actual fire tests where a temperature of 1,700° F. or more has been maintained for a period of five hours, has been either in walls or ceilings 1 inch to 1½ inches. Also by the examination of actual conflagrations, such as that at Baltimore and elsewhere, it has been apparent that the prearranged fire tests are more severe in the results shown by the structure than actual conflagrations.

"Before concrete will disintegrate when exposed to fire the large amount of moisture chemically combined in the setting of the cement—being 20 to 25 per cent of its weight—has to be driven off by heat and then the vapor thus driven off has to be evaporated from the pores of the concrete before it becomes sufficiently hot to crumble. The slowness of evaporating this vapor is probably the cause of concrete resisting extremely high temperatures for a few hours, while a much lower temperature, if long continued, would ultimately disintegrate it. Cement will resist 500° F. for an indefinite period while a continuous temperature of 700° F. is disastrous. The cement coating of the stones of the concrete will resist the attack of fire so long that it is of less consequence whether the stone can be damaged by fire or not. Thus pure limestone is a most excellent aggregate and will not decompose until after the cement, and after the cement has gone it is immaterial what aggregate is used, for the work has then failed anyway." * * * * *

INDEX

INDEX

A

	PART	PAGE
American vs. foreign fire losses	I,	58
Architects, attitude of	II,	51

B

Baltimore fire	I,	10
Building conditions in American cities	II,	12
comparisons of conditions here and in Europe	II,	14
good buildings skimped	II,	13
large proportion of poor buildings	II,	12
Building construction, evolution of	II,	55
corrugated and plate floor construction	II,	63
early forms	II,	55
mill construction	II,	64
other retardants	II,	69
reinforced concrete	II,	72
steel-frame buildings	II,	69
steel and tile vs. reinforced concrete	II,	80
stone and brick	II,	57
tile protection	II,	60
unprotected iron and steel	II,	57
Building materials, standard tests of	II,	136
Building, labeling	II,	5

C

"City unburnable" a possibility	II,	44
attitude of architects	II,	51
municipal building regulations	II,	45
Concrete from the fire-resisting standpoint	II,	151
concrete as a building material	II,	151
behavior under fire	II,	152
Portland cement concrete	II,	151
quality of	II,	152
reinforced concrete	II,	151
construction developments due to concrete	II,	153
applications of concrete	II,	154
early forms	II,	153
fire-resisting qualities	II,	159
Concrete blocks	II,	189
Concrete buildings	II,	187

	PART	PAGE
"Concrete" fires	II,	166
concrete cottage at Winthrop beach	II,	179
Dayton motor car works	II,	169
F. B. Klock building	II,	183
F. W. Tunnell and Company building	II,	175
Huyler candy factory	II,	166
McCray, Morrison and Company elevator	II,	186
N. F. P. A. report	II,	187
Pacific coast borax company's building	II,	186
Peavey Elevator Company	II,	166
Rubber reclaiming manufacturing plant	II,	184
Thompson and Norris building	II,	175
Conflagrations	I,	2
Baltimore fire	I,	10
San Francisco fire calamity	I,	26
Corrugated and plate floor construction	II,	63

F

Fire, causes of	I,	75
new inventions bring new hazards	I,	77
primary	I,	75
secondary	I,	76
Fire, havoc of	I,	51
American vs. foreign fire losses	I,	58
analysis of fire losses in U. S.	I,	59
comparative figures	I,	65
losses in treeless states vs. losses in timber states	I,	63
depletion of timber and iron supply and its remedy	I,	67
fireproof construction the only adequate protection	I,	71
one year's fire losses	I,	55
waste of life and property	I,	51
Fire extinction	I,	80
Fire and fire losses	I,	1–94
causes of fire	I,	75
conflagrations	I,	2
fire extinction	I,	80
fire's havoc	I,	51
insurance idea	I,	82
Fire limits	II,	47
Fire records and tests	II,	166
"concrete" fires	II,	166
laboratory tests	II,	193
Fire-resisting qualities	II,	159
Fireproof building	II,	32, 97
building code	II,	132
contents and finish of buildings	II,	36

	PART	PAGE
Fireproof building		
division of building into isolated units	II,	36
external light-courts	II,	106
fireproof homes	II,	115
fireproof house plans	II,	121
furnishings	II,	111
general fireproof features	II,	109
halls and exits	II,	106
ornamental surfaces	II,	97
outside walls	II,	97
piers and foundations	II,	103
popular misconceptions	II,	33
non-combustible material	II,	33
unprotected iron and steel	II,	33
roofing	II,	103
shafts	II,	108
special requirements	II,	111
assembly halls	II,	113
church	II,	113
hotels	II,	113
theater	II,	111
stairs and elevator shafts	II,	106
steel and tile or concrete frame	II,	41
structural parts	II,	105
floors	II,	105
tile protection	II,	105
use of wood	II,	108
wall finish	II,	109
wall openings	II,	99
door and window shutters	II,	99
skylights and transoms	II,	102
wire glass, metal doors, and other protective features	II,	43
Fireproof construction	II,	1–205
"city unburnable" a possibility	II,	44
concrete from the fire-resisting standpoint	II,	151
fire records and tests	II,	166
fireproof building in detail	II,	97
our national progress	II,	55
present building conditions in American cities	II,	12
retarding fires	II,	145
standard tests of building materials	II,	136
stimulus to good building	II,	1
value of	II,	15
fireproofing as an investment	II,	16
importance of good design	II,	16
insurance vs. fireproof construction	II,	20
what is fireproof building	II,	32

I

	PART	PAGE
Insurance vs. fireproof construction	II,	20
fallacious arguments against fireproofing	II,	25
fireproofing real economy	II,	27
ignorance retards spread of fireproof methods	II,	29
Insurance idea	I,	82
Iron and steel (unprotected)	II,	57

L

Laboratory tests to determine fire resisting qualities, etc.	II,	193
further tests	II,	205
panel 17	II,	196
materials	II,	196
results	II,	197
test	II,	197
panel 18	II,	200
material	II,	200
results	II,	201
test	II,	200
panel 19	II,	202
material	II,	202
results	II,	202
test	II,	202
panel 20	II,	203
material	II,	203
results	II,	204
test	II,	204
Legislative control of building	II,	2

M

Metal doors	II,	43
Mill construction	II,	64
Municipal building regulations	II,	45
fire limits	II,	47
inspection	II,	47

N

N. F. P. A. report	II,	187
concrete blocks	II,	189
concrete buildings	II,	187
National progress in fireproof construction	II,	55
Neighboring liability .... I, 93	II,	6

R

Reinforced concrete	II,	72
concrete design not yet standardized	II,	76
concrete a potent material	II,	72
limitations of concrete	II,	78

	PART	PAGE
Reinforced concrete		
skilled labor and great care necessary	II,	76
uses of cement	II,	74
Retarding fires	II,	145
S		
San Francisco fire calamity	I,	26
Steel-frame buildings	II,	69
Steel and tile or concrete frame	II,	41
Steel and tile vs. reinforced concrete	II,	80
Stimulus to good building	II,	1
labeling buildings	II,	5
legislative control	II,	2
neighboring liability	II,	6
public opinion	II,	6
remission of taxes	II.	4
T		
Table		
fire data (foreign)	I,	58
fire data United States	I,	59
fire loss per capita—United States	I,	64
fire loss in timber states	I,	63
fire loss in treeless states	I,	63
great fires of the past 80 years	I,	9
Taxes, remission of	II,	4
Tile protection	II,	60
W		
Wire glass	II,	43

Partial List of Titles and Authors—Continued

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