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THE FIRE TAX AND WASTE OF STRUCTURAL MATERIALS IN THE UNITED STATES

BY

HERBERT M. WILSON

AND

JOHN L. COCHRANE

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THE FIRE TAX AND WASTE OF STRUCTURAL MATERIALS IN THE UNITED STATES.

By H. M. WILSON and J. L. COCHRANE.

PURPOSE OF THE INVESTIGATION.

The United States Government is the owner of buildings costing more than $300,000,000 and is spending each year more than $20,000,000 in new buildings. In the construction of these buildings the Government endeavors to maintain as high a standard of efficiency as can be obtained with economical design, for all of them are intended to be of a permanent and enduring nature. This work is of such magnitude and importance that the Government can afford to take no risks either in methods of construction or in materials to be used; therefore it has been found necessary to make a general investigation of materials used in construction work.

An important part of the investigation is designed to show the fire resistance or the fireproof qualities of the materials employed and their strength at different temperatures. The Government does not insure its buildings against loss by fire but endeavors to provide against such loss by making them fireproof, for the expense of insurance would be very great. It is estimated that if the public buildings of the United States were insured it would cost the Government more than $600,000 each year.

The Geological Survey, through its technologic branch, has been charged with the conduct of these investigations, which include tests of the fire-resisting and fireproofing qualities of building stones, brick, architectural tile, reinforced concrete, and other materials—tests made with a view to procuring information for the Supervising Architect of the Treasury, who has under his care buildings valued at more than $200,000,000. In some of these tests the materials are subjected to ordinary fire temperature—about 1,000° F.—and to conflagration temperatures of about 1,700°; and the heated material is then drenched with water from a fire hose and its behavior is observed. Measurements are also made of the rate at which temperatures are transmitted from fire on one side to the other side of walls constructed of various materials and of different thicknesses. The purpose of these investigations is to meet the Government's own

needs as the greatest consumer of structural materials, but the results will be generally useful to States and municipalities and to the people of the whole country.

The results already obtained direct attention to the necessity of using cheaper fireproof materials, so that property owners may be encouraged to construct buildings that will better resist fire. They also show the necessity of better building codes in cities and especially of a better enforcement of the codes already enacted if the present enormous fire losses are to be diminished. The investigations indicate that fireproof buildings will be constructed at less expense in the future than in the past, and that the difference in cost between fireproof and inflammable buildings will soon cease to be an encouragement to flimsy construction.

SCOPE AND GENERAL RESULTS OF INQUIRY.

The contrast between the small losses by fire to government buildings, due to the great care taken to make them fireproof, and the immense losses reported from the country as a whole led the Geological Survey to conduct an inquiry into fire losses in the United States and their exact cost to the people. This inquiry covered not only the value of the property destroyed by fire but also the cost of maintaining fire departments, the amount of insurance premiums paid less the amounts returned, the cost of protective agencies, the additional cost of water supplies, etc.

The investigation disclosed the fact that the total cost of fires in the United States in 1907 amounted to almost one-half the cost of new buildings constructed in the country for the year. The total cost of the fires, excluding that of forest fires and marine losses but including excess cost of fire protection due to bad construction, and excess premiums over insurance paid, amounted to over $456,485,000, a tax on the people exceeding the total value of the gold, silver, copper, and petroleum produced in the United States in that year. The cost of building construction in forty-nine leading cities of the United States reporting a total population of less than 18,000,000 amounted, in 1907, to $661,076,286, and the cost of building construction for the entire country in the same year is conservatively estimated at $1,000,000,000. Thus it will be seen that nearly one-half the value of all the new buildings constructed within one year is destroyed by fire. The total fire cost in this country is five times as much per capita as in any country of Europe. This fire cost was greater than the value of the real property and improvements in any one of the following States: Maine, West Virginia, North Carolina, North Dakota, South Dakota, Alabama, Louisiana, Montana.

The actual fire losses due to the destruction of buildings and their contents amounted to $215,084,709, a per capita loss for the United

States of $2.51. The per capita losses in the cities of the six leading European countries amounted to but 33 cents, or about one-eighth of the per capita loss sustained in the United States. In addition to this waste of wealth and natural resources, 1,449 persons were killed and 5,654 were injured in fires.

COOPERATION BY EXPERTS.

The data on which the present report is based were the result of a statistical inquiry which involved the mailing of about 20,000 circulars and the tabulation and study of the resulting replies. Careful study was also made of the statistics gathered by the Fire Underwriters' Association in its reports on conflagration hazards, the statistics of the Spectators' Year Book, the Chronicle fire tables, and the census reports.

As a preliminary to this inquiry, personal interviews were had, early in 1908, with a number of persons qualified to advise as to the scope and character of the investigation. Valuable suggestions were received regarding the inquiry into fire losses from Messrs. Charles A. Hexamer, chairman board of consulting experts, National Board of Fire Underwriters, Philadelphia; C. U. Crosby, chairman National Fire Protective Association, New York; H. K. Miller, general agent National Board of Fire Underwriters' Association, New York; George W. Babb, chairman executive committee, National Board of Fire Underwriters' Association, New York; J. E. Curtis, consulting engineer, Fire Protective Association, New York; and W. H. Merrill, manager Underwriters' Laboratories, Chicago.

Advice and suggestions regarding the nature of the inquiry and the conditions affecting the design of public water supplies, with a view to separating the items which may properly be considered as chargeable to domestic service and ordinary fire protection from the additional expenditures involved in procuring water supplies adequate to the prevention of conflagrations, were received from Prof. George F. Swain, Massachusetts Institute of Technology, Boston, Mass.; Messrs. John R. Freeman, consulting hydraulic engineer, Providence, R. I.; John T. Fanning, consulting engineer, Minneapolis, Minn.; Ben C. Adkins, city engineer, St. Louis, Mo.; Walter H. McFarland, superintendent water department, Washington, D. C.; and a number of other hydraulic engineers and superintendents of waterworks, who offered to furnish valuable information and to comment on the replies received.

To all of the above and to the many others who furnished assistance and advice in connection with replies to the circulars of inquiry the authors are indebted and wish to express their regret that the limited time and funds available have prevented the gathering of more complete data.

METHOD OF GATHERING STATISTICS.

SOURCES OF STATISTICS FOR CITIES.

Requests for official records of fire loss were sent to the chiefs of fire departments in 5,175 incorporated places in the United States (all places having a population of 1,000 or more), with the result that 1,000 replies were received. Four thousand second requests were sent out, and to these 1,796 fire chiefs responded, making a total of 2,796 cities and villages heard from out of 5,175. These 2,796 cities and villages contain a population of 34,102,453.

A sample of the form sent to fire chiefs is given below.

No. ..... (Confidential.)

[Return this sheet to the United States Geological Survey (Technologic Branch).]

STATISTICS OF LOSSES BY FIRE AND CAUSES OF FIRES DURING CALENDAR YEAR 1907.

City, ... County, ... State, ...

LOSSES BY FIRE.

Total fire loss on buildings, $..... On contents, $.....
Fires in fireproof buildings (brick, iron, stone), No. ..... Loss on these buildings, $..... On contents, $.....
Fires in partially fireproof buildings, No. ..... Loss on buildings, $..... On contents, $.....
Fires in frame buildings, No. ..... Loss on buildings, $..... On contents, $.....
Fires confined to building or place of origin, No. ..... Fires extending to adjoining buildings, No. .....
Losses on buildings and contents in which fires originated, $..... Exposure losses, i. e., on adjoining buildings and contents, $.....
Lives lost in fires (including firemen), No. ..... Persons injured, No. .....
Total cost of maintenance of fire departments, $..... Cost of private fire protection, automatic sprinklers, watchmen, etc., in your city, $.....

CAUSES OF FIRES.

Defective flues, No. ..... Incendiary, No. ..... Unknown, No. .....
Date, ...
Signature of the person furnishing information: .....

NOTE: Please send your annual report for 1907, in addition to answering these questions, to H. M. WILSON, Chief Engineer, Technologic Branch, U. S. Geological Survey, Washington, D. C.

It was with the greatest difficulty that figures were obtained showing separately the losses on frame and brick buildings, on buildings and contents, and the losses on buildings in which fire did not originate, many of the fire chiefs sending merely an estimate of the total loss. After much correspondence 2,300 out of the 2,796 chiefs who replied originally gave the detailed figures.

SOURCES OF STATISTICS FOR RURAL DISTRICTS.

In order to obtain a correct estimate of the losses in the rural districts, 5,000 blanks were sent to postmasters located in counties that were strictly rural, the aim being to exclude all counties that contained large villages. The blanks were apportioned among the various States according to their percentages of rural population, the State with a large farming population getting more than the State whose population centered mainly in the cities. Responses were received from 1,898 postmasters, representing a population of 1,410,383.

A sample of the form sent to postmasters is given below.

No. ..... (Confidential.)

[Return this sheet to the United States Geological Survey (Technologic Branch).]

STATISTICS OF LOSSES BY FIRE AND CAUSES OF FIRES DURING CALENDAR YEAR 1907.

Township or district, ... State, ... Population, ...

LOSSES BY FIRE.

Total fire loss on buildings, $..... On contents, $.....
Frame buildings burned, No. ..... Loss on frame buildings, $..... On contents, $.....
Loss from haystack fires, $.....
Lives lost in fires, No. .....
Persons injured, No. .....

CAUSES OF FIRES.

Lightning, No. ..... Incendiary, No. ..... Lamps, No. ..... Unknown, No. .....
Date, ...
Signature of the person furnishing information: .....

Thus it will be seen that reports were received from 4,694 cities, villages, and rural communities having a total population of 35,512,836.

SOURCES OF STATISTICS SHOWING COST OF FIRE PROTECTION.

In order to ascertain the cost imposed upon the country by fires above that represented by simple fire waste or destruction of property and the cost of public fire fighting departments, insurance losses, etc., careful statistical inquiry was made as to the additional cost of constructing and maintaining city water supplies required for protection against conflagration above the cost requisite to proper domestic supply, street sprinkling, and the incidental fire service necessary to restrict a fire within the building in which it originates. Information was also procured regarding the cost of private fire protective measures—such as automatic fire sprinklers, fire extinguishers and

grenades, private watchmen's services—imposed by the risks of inflammable construction, and the losses to the country from marine fires and disasters.

Endeavors to procure data showing the cost of private fire protection were not very successful, for the statements received from the manufacturers of automatic sprinklers, fire extinguishers, etc., were only estimates of the cost of private watch service derived from special investigations.

Data of losses from marine disasters were procured by obtaining the total amount of insurance paid by American companies and the total amount paid by foreign companies doing United States business.

Five thousand seven hundred blank reports were mailed to engineers and superintendents of waterworks in an endeavor to obtain information with respect to the cost of constructing each plant, the amount chargeable to domestic service, and the amount chargeable to fire service, as shown in the following blank:

No. .....

[Return this sheet to the United States Geological Survey (Technologic Branch).]

1. Name of city, ... State, ...
2. Population, ... Year, 19..
3. a. Total estimated cost of distributing system, $.....
   b. Number of feet of various sizes of pipe in distributing system or tons of metal in same, ...
   c. Estimated cost of distributing system if necessaity for fire service were omitted and only domestic supply required, $.....
   d. Weight of metal under same conditions, ... tons.
4. a. Total estimated cost of water supply, by pumping or reservoirs and gravity flow, for above distributing system, $.....
   b. Estimated cost for domestic requirements only (see 3 c), $.....
5. a. Total number of fire hydrants in your system (3 a), ...
   b. How many could be dispensed with (see 3 c), ...
6. If you have or contemplate a separate high-pressure fire system, what is its estimated value? $.....

The above data may, if you prefer, be given on the basis of cost per capita for each item.

(Signed) .....

Address .....

....., 1908.

Fifteen hundred replies were received, only a small percentage of which were complete enough for use in tabulation. The total cost of such water supplies was therefore obtained from the census reports on municipal finance for cities having a population of over 30,000 and owning waterworks; the remainder of the data was obtained from the Spectator's Yearbook.

The total cost of waterworks systems in the United States, as thus determined, was segregated to show the total cost in each of five geographical districts of the United States, namely, the Middle and New England States, the Southern and Southeastern States, the Central States, the Rocky Mountain or arid region, and the Pacific Slope States, as the cost differs greatly in different sections of the country.

The total cost of the waterworks systems in each of the geographical divisions was then subdivided to show the total cost in cities according to the following classification by population: (1) 100,000 or more; (2) 30,000 to 100,000; (3) 5,000 to 30,000; (4) under 5,000.

This same classification was followed in tabulating the reports received from engineers and superintendents who gave in detail the information sought. This detailed information for each geographical division and each class of cities was then applied to the total cost of waterworks systems for the corresponding geographical divisions and class of cities.

The statistics gathered show the additional cost necessitated by fire protection. These results are not based on the idea that waterworks are constructed for two purposes of equal importance, namely, domestic water service and fire protection service; nor on the assumed cost of constructing a waterworks system for fire protection alone; they are presented rather with the idea of showing how much additional expense was incurred in construction in order to secure ample protection against conflagrations.

RESULTS OF THE INQUIRY.

THE FIRE WASTE IN THE UNITED STATES.

AMOUNT OF THE FIRE TAX.

The 2,976 cities and villages from which reports were received, with a population aggregating 34,102,453, reported a fire loss of $86,476,029, a per capita loss of $2.54; the postmasters in rural districts reported a total loss of $3,519,769, a per capita loss of $2.49; making a total loss of $89,995,798, a per capita loss for cities, villages, and rural districts from which returns were received of $2.51, an index sum that would give an aggregate loss for the United States in 1907 of $215,084,709. The significance of these figures is realized when it is known that the average per capita loss in the cities of the six leading nations of Europe amounts to 33 cents.

The total loss on buildings in the United States was $109,156,894 and on contents $105,927,815. There were fires in 36,140 brick, iron, and stone buildings, with a loss of $31,092,687 on the buildings and $37,332,580 on the contents, and in 129,117 frame buildings, with a loss of $78,064,207 on the buildings and $68,595,235 on the contents. In

cities and villages with a population of 1,000 or more there were 6,324 fires that extended beyond the building of origin, with a total exposure loss of $13,913,694. The loss on fires that were confined to the building of origin in the cities and villages amounted to $93,179,589.

In addition to the great loss of property, 1,449 persons lost their lives in fires during the year and 5,654 were injured.

In discussing this waste, Mr. Charles Whiting Baker, editor of the Engineering News, New York, in an address before the national engineering societies on "Conservation of natural resources," March 24, 1909, said:

"The buildings consumed, if placed on lots of 65 feet frontage, would line both sides of a street extending from New York to Chicago. A person journeying along this street of desolation would pass in every thousand feet a ruin from which an injured person was taken. At every three-quarters of a mile in this journey he would encounter the charred remains of a human being who had been burned to death."

The fire losses are summarized in Table 1.

TABLE 1.—*Fire losses in the United States for 1907.*

[Statistics gathered by the United States Geological Survey.]

	Total.	Urban.	Rural.
Total fire loss	$215,084,709	$107,093,283	$107,991,426
Buildings	109,156,894	50,173,625	58,983,269
Contents	105,927,815	56,919,558	49,008,157
Brick, etc., buildings	68,425,267	48,908,744	19,516,523
Buildings	31,092,687	19,816,474	11,276,213
Contents	37,332,580	29,092,270	8,240,310
Frame buildings	146,659,442	58,184,539	88,474,903
Buildings	78,064,207	30,357,151	47,707,056
Contents	68,595,235	27,827,388	40,767,847
Number of fires	165,257	105,406	59,851
Number of fires in brick, etc., buildings	36,140	25,297	10,843
Number of fires in frame buildings	129,117	80,109	49,008
Loss per capita	2.51	2.54	2.49

The total loss from fire in the United States during 1907, $215,084,709, represents a waste of nearly $600,000 for every day of the year, of $25,000 for every hour of the day. The term "waste" is used because the fire loss is absolutely irretrievable and constitutes a tremendous drain upon the natural resources of the country. The insurance on a burned building does not bring back the property that was destroyed; it simply equalizes the loss between all others whose property is insured. And the money paid by the insurance companies does not by any means cover the total losses sustained. Some underwriters declare that from 75 to 80 per cent of all property

is insured, but two state fire marshals disagree with this statement after tabulating the fire losses for their states. D. S. Creamer, the state fire marshal of Ohio, finds that but 52 per cent of the property is covered by insurance. This statement seems to be borne out by the annual report of the National Board of Fire Underwriters for 1907, which gives as the total losses paid by all companies during the year, $114,164,469.

The fire waste for the last thirty-three years, according to the National Board of Fire Underwriters, reached the tremendous total of $4,484,326,831.

Fearful as it is to contemplate this great destruction of the natural resources of this country, the situation becomes more appalling when it is realized that this waste is increasing by leaps and bounds with each succeeding year. The National Board of Fire Underwriters gives the following estimates of the fire waste for the last thirty-three years:

TABLE 2.—*Annual fire losses in the United States for thirty-three years, 1875–1907.*

[Compiled by the National Board of Fire Underwriters.]

Year.	Loss.	Year.	Loss.	Year.	Loss.
1875	$78,102,285	1886	$104,924,750	1897	$116,354,575
1876	64,630,600	1887	120,283,055	1898	130,593,905
1877	68,265,800	1888	110,885,665	1899	153,597,830
1878	64,315,900	1889	123,046,833	1900	160,929,805
1879	77,703,700	1890	108,993,792	1901	165,817,810
1880	74,643,400	1891	143,764,967	1902	161,078,040
1881	81,280,900	1892	151,516,098	1903	145,302,155
1882	84,505,024	1893	167,544,370	1904	229,198,050
1883	100,149,228	1894	140,006,484	1905	165,221,650
1884	110,008,611	1895	142,110,233	1906	518,611,800
1885	102,818,796	1896	118,737,420	1907	199,383,300

In the last thirty-three years, therefore, as shown by Table 2, the total value of property destroyed by fire amounted to $4,484,000,000, and the figures obtained in this inquiry show that it is reasonable to assume that fully as much money was spent in fire protection, making a total of almost $9,000,000,000 in thirty-three years.

ANALYSIS OF FIRE LOSSES IN THE UNITED STATES.

LOSSES ON FRAME AND BRICK BUILDINGS IN CITY AND COUNTRY.

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 fireproof 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.

It will be seen from Table 1 (p. 12) that 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 large 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 property 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.

LOSSES BY CONFLAGRATIONS.

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 notable conflagrations of the United States have been those at Chicago in 1871; Boston, 1872; Baltimore, 1904; and San Francisco on April 18, 1906. The earthquake and fire at San Francisco resulted in a total property loss of $350,000,000, exceeding in amount that of any previous similar disaster in the history of the world.

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.

The Ohio fire marshal, in his annual report for 1907, in urging new building codes for Cleveland and Cincinnati, the two largest cities of the State, says: "Either city may at any time suffer a conflagration costing $300,000,000."

The October, 1908, quarterly of the National Fire Protection Association says:

> The average American city is full of fire traps. Buildings of great areas without fire cut-offs, with large floor openings, with unprotected windows, and with very combustible contents are too numerous to prove the exception to any rule. These are conflagration breeders. Fire travels through them rapidly and under certain conditions can get beyond even the best fire department, and, sweeping through the unprotected windows of surrounding buildings, will soon cause a conflagration.

LIVES LOST.

During the year 1907, according to information gathered by the United States Geological Survey, fires caused the death of 1,449 persons and the injury of 5,654. These figures are incomplete and perhaps do not represent more than half the persons who were

victims of fires. Many fire chiefs of large cities failed to report any deaths because such were not properly included in their annual reports. It is safe to assume that with the fire losses of the United States from five to seven times as great as those in Europe, the number of persons killed and injured here is from five to seven times greater than in Europe. The cause of this again, in many instances, is faulty construction of buildings and inappreciation on the part of cities of the responsibility to safeguard the lives of their citizens, or ignorance of what is demanded to protect against fire.

The fire at the Iroquois theater in Chicago, December 30, 1903, in which 600 persons lost their lives, was a terrible object lesson, yet this was not sufficient to stop these disasters. January 13, 1908, fire in an opera house at Boyertown, Pa., cost the lives of nearly 200 women and children. Two months later, March 4, 1908, 165 children were burned to death in a schoolhouse at Collinwood, Ohio. If the buildings destroyed had been properly constructed and equipped none of these lives would have been lost.

CAUSES OF THE FIRE WASTE IN THE UNITED STATES.

FRAME BUILDINGS.

The great fire waste in the United States is undoubtedly due to the predominance of frame buildings. In most European cities frame buildings are positively prohibited within the limits of municipalities, and but very few are erected in the rural districts, owing to the scarcity and the high price of timber. In the United States the conditions have been exactly reversed. Lumber, at least until recently, has been the cheaper material, besides being more easily worked than brick, stone, or steel. The result has been that the greater number of the homes of the country and many factory buildings, warehouses, etc., have been made out of lumber.

Of the total losses sustained in the United States in 1907 more than two-thirds was due to the construction of frame buildings. The exact losses were $146,695,442 in frame buildings and $68,425,267 in brick, stone, and steel buildings, as shown by Table 3.

TABLE 3.—*Fire losses in the United States in 1907 in brick, iron, and stone buildings, as compared with those in frame buildings.*

[Statistics gathered by the United States Geological Survey.]

Number of fires in frame buildings	129,117
Number of fires in brick, iron, and stone buildings	36,140

	Losses on brick, iron, and stone buildings.	Losses on frame buildings.
Building loss	$31,092,687	$78,064,207
Loss on contents	37,332,580	68,595,442
	68,425,267	146,659,649

Another illustration of the influence of frame buildings on the fire loss of the country is suggested by grouping 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. The States in which there is a supply of lumber show an increased per capita loss of 59 cents over the per capita of the treeless States, as seen by Table 4.

TABLE 4.—*Per capita fire loss for 1907 in eleven States where timber is scarce and in eleven States where timber is plentiful.*

[Statistics gathered by the United States Geological Survey.]

	Total population.	Total fire loss.	Loss per capita.
Group 1. States in which timber is scarce: Iowa, Illinois, Oklahoma, Connecticut, Delaware, New Jersey, South Dakota, Rhode Island, Kansas, Nebraska, and North Dakota	16,785,460	$38,606,558	$2.30
Group 2. States in which timber is plentiful: Washington, Louisiana, Texas, Mississippi, Wisconsin, Arkansas, Michigan, Pennsylvania, Minnesota, Oregon, and North Carolina.	25,569,533	73,895,950	2.89

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 5.

TABLE 5.—*Per capita fire losses for 1907 in the United States by geographical divisions.*

[Statistics gathered by the United States Geological Survey.]

Geographic division.	Total population.	Total fire loss.	Fire 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	59,908,922	3.66
Western: Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Washington, Oregon, and California	4,783,557	12,676,426	2.65

FAULTY CONSTRUCTION.

Although the prevailing use of lumber as a material of construction is one cause of the great fire waste of the United States, there is another cause lying back of this—faulty construction and equipment. The list of causes of fires is headed by defective chimneys, flues, fireplaces, and heating and lighting apparatus—faults of construction and equipment. Matches, sparks, and explosions figure prominently in the list and are followed by incendiarism, electricity, and lightning. Nearly one-fourth of the fires are labeled "unknown cause," which indicates forcibly the listless attitude not only of the general public toward this waste, but also of the men who are directly charged with protecting property against fire—the officials of municipalities and others.

COST OF FIRE PROTECTION.

The incidental losses by fire comprise the insurance loss—the difference between the total premiums paid and the amounts paid to the insured; the annual expense of so much of the city water-supply service as is primarily necessary to furnish fire protection, in excess of the service estimated as necessary for domestic consumption; the annual expense of fire departments, and the annual expense of private fire protection.

COST OF INCREASED WATER SUPPLY.

To the question, What proportion of the cost of construction of waterworks should be legitimately charged to domestic service and what proportion to fire-protection service? engineers generally will reply that the cost should be equally divided except in the larger cities, where a much greater proportion should be charged to domestic service.

The results of this inquiry, incomplete though it is, would indicate that, for the whole United States, an average of 22 per cent of the total expenditure for public water supplies, or less than one-fourth of the total cost of waterworks systems, is due to additional supplies necessary for protection against fires of such magnitude as may be propagated beyond the building of origin. The distribution of the cost of waterworks systems is shown in Table 6.

TABLE 6.—*Cost of construction of waterworks systems, 1907.*

CLASSIFICATION BY SIZE OF CITIES.

	Cost per capita.	Total cost of system.	Amount chargeable to domestic service.	Amount chargeable to fire service.	Cost of entire distributing system.
Total for United States	$27.21	$1,129,247,532	$883,575,856	$245,671,676	$468,022,552
100,000 and over	32.72	591,222,244	501,528,003	89,694,241	223,965,694
30,000 to 100,000	29.06	184,803,174	141,922,615	42,880,559	86,195,257
5,000 to 30,000	23.60	235,718,456	160,973,462	74,744,996	102,127,820
Under 5,000	16.59	117,503,268	79,151,776	86,351,492	55,733,781

TABLE 6.—*Cost of construction of waterworks systems, 1907*—Continued.

CLASSIFICATION BY SIZE OF CITIES—Continued.

	Total tons of pipe.	Distributing system chargeable to domestic service.	Tons of pipe, domestic.	Distributing system chargeable to fire.	Tons of pipe, fire.	Source of water supply.
Total for United States...	7,097,800	$340,785,884	5,080,873	$127,236,668	2,016,927	$609,272,192
100,000 and over	2,940,147	172,885,262	2,124,536	51,080,432	815,611	339,069,350
30,000 to 100,000	1,696,756	62,772,404	1,261,173	23,422,853	435,583	91,276,397
5,000 to 30,000	1,695,237	67,167,220	1,174,753	34,960,600	520,484	124,089,798
Under 5,000	765,660	37,960,998	520,411	17,772,783	245,249	54,835,647

	Source of water supply, domestic.	Source of water supply, fire.	Number of hydrants.	Number of hydrants, fire service.	Cost of hydrants, fire service.	Value of established or contemplated high-pressure fire system.
Total for United States...	$542,789,972	$66,482,220	420,394	350,152	$29,761,400	$22,191,388
100,000 and over	326,642,741	10,426,609	130,366	82,462	8,246,200	19,941,388
30,000 to 100,000	79,150,211	12,128,186	70,756	63,494	5,079,520	2,250,000
5,000 to 30,000	93,806,242	30,282,556	131,713	118,773	9,501,840	.....
Under 5,000	41,190,778	13,644,869	87,559	85,423	6,933,840	.....

CLASSIFICATION BY GEOGRAPHICAL DIVISIONS.

	Cost per capita.	Total cost of system.	Amount chargeable to domestic service.	Amount chargeable to fire service.	Cost of entire distributing system.
Total for United States	$27.21	$1,129,247,532	$883,575,856	$245,671,676	$468,022,552
Middle and New England States	32.19	623,221,159	513,311,626	109,909,533	221,338,976
Central States	20.35	308,163,578	222,577,226	85,586,352	158,648,237
Southern and Southeastern States	19.34	75,737,475	52,755,453	22,982,022	36,362,061
Rocky Mountain and Western States	63.77	60,509,780	48,402,652	12,107,128	25,920,674
Pacific Slope States	28.96	61,615,540	46,528,899	15,086,641	25,752,604

	Total tons of pipe.	Distributing system chargeable to domestic service.	Tons of pipe, domestic.	Distributing system chargeable to fire.	Tons of pipe, fire.	Source of water supply.
Total for United States...	7,097,800	$340,785,884	5,080,873	$127,236,668	2,016,927	$609,272,192
Middle and New England States	2,897,936	167,435,756	2,117,261	53,903,220	780,675	374,435,475
Central States	2,747,968	111,455,490	1,925,764	47,192,747	822,204	134,312,281
Southern and Southeastern States	576,568	24,467,490	398,775	11,894,571	177,793	34,619,874
Rocky Mountain and Western States	457,639	18,979,767	323,624	6,940,907	134,015	30,903,186
Pacific Slope States	417,689	18,447,381	315,449	7,305,223	102,240	35,001,376

	Source of water supply, domestic.	Source of water supply, fire.	Number of hydrants.	Number of hydrants, fire service.	Cost of hydrants, fire service.	Value of established or contemplated high-pressure fire system.
Total for United States...	$542,789,972	$66,482,220	420,394	350,152	$29,761,400	$22,191,388
Middle and New England States	345,875,870	28,559,605	123,855	108,879	9,248,320	18,198,388
Central States	111,121,736	23,190,545	186,730	148,496	12,710,060	2,493,000
Southern and Southeastern States	28,287,963	6,331,911	40,540	37,090	3,255,540	1,500,000
Rocky Mountain and Western States	29,422,885	1,480,301	46,894	45,249	3,685,920	.....
Pacific Slope States	28,081,518	6,919,858	22,375	10,438	861,560	.....

EXCESSIVE COST OF MAINTAINING FIRE DEPARTMENTS.

It will be incidentally noted that fire protection involves the use of 2,000,000 tons of metal, having a value in excess of $127,000,000, and the metal in 350,000 hydrants, having a value of $30,000,000, all of which is wasted on account of the need of preparing to fight fires of a kind which, because of the inflammable character of building construction in this country, would develop into conflagrations without adequate water service and fire departments.

The capital invested for fire protection and the annual loss and expense on account of fire in the United States in 1907 is shown in Table 7.

TABLE 7.—*Capital invested for fire protection and annual loss and expense on account of fire in the United States, 1907.*

	Investment in construction and equipment.	Annual loss and expense.
FIRE LOSS.		
Total fire loss		$215,084,709
FIRE PROTECTION.		
Insurance.		
Amount of fire premiums paid above amount of losses paid		[a] 145,604,362
Waterworks.		
Total cost of waterworks chargeable to fire service	[b] $245,671,676	
Source of water supply $66,482,220		
Distributing system (2,016,927 tons of metal) 127,236,668		
Hydrants (350,152) 29,761,400		
Separate high-pressure fire service 22,191,388		
Total annual expense of waterworks chargeable to fire service		28,856,235
Depreciation and taxes $10,563,881		
Interest charge [c] 9,826,867		
Maintenance 8,465,487		
Fire departments.		
Total cost of fire departments	107,063,524	
Total annual expense of fire departments		48,940,845
Depreciation and taxes $4,603,731		
Interest charge [d] 4,282,540		
Maintenance 40,054,574		
Private fire protection.		
Total cost of private fire extinguishers, automatic sprinklers, etc	50,000,000	
Total annual expense of private fire protection [e]		18,000,000
	402,735,200	456,486,151

[a] The amount paid by insurance companies on account of fire loss was $114,164,469, and the amount received by them in premiums was $259,768,831.

[b] This is 22 per cent of the total cost of water systems, domestic and fire service combined.

[c] $245,671,676, cost of waterworks chargeable to fire service, capitalized at 4 per cent, is equal to an annual charge of $9,826,867.

[d] $107,063,524, cost of fire departments, capitalized at 4 per cent, is equal to an annual charge of $4,282,540.

[e] Interest on investment, cost of watchmen, etc.

COST OF PRIVATE FIRE PROTECTION.

The estimated cost of private fire protection, including capital invested in construction and equipment, aggregates about $50,000,000, and the annual interest on this sum and the annual cost of watchmen's services amount to about $18,000,000.

MARINE LOSSES.

The data procured to show losses by marine disasters give an aggregate for the year 1907 of $11,621,827, representing the total amount of insurance paid by American companies and the total amount paid by foreign companies doing business in the United States. A portion of this amount, however, may include some Canadian insurance or some duplication.

THE FIRE WASTE IN EUROPEAN CITIES.

The inquiry covered not only the cost of fires in the United States, but also the general cost in Europe. In 1905 the Bureau of Manufactures of the Department of Commerce and Labor sent letters of instruction to all the principal United States consular officers in Europe requesting information concerning the fire losses in European cities; also a statement regarding the fire-insurance practice in those cities. Unfortunately, the statistics gathered were not all for the same year, some cities reporting for 1901, others for 1903, and still others for 1904, and a few failing to make any report. It is stated, however, that there is but little variation from year to year in the fire losses of the European cities, and for this reason the figures were tabulated.

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 it did.

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.

Consul Hossfeld, of Trieste, Austria-Hungary, in his official report to the State Department on the fire losses in the city he represents, said:

> The laws of Trieste and its territory prohibit the construction of wooden buildings. Only sheds and buildings of a temporary nature may be constructed of wood, such as are intended to serve as a shelter for workmen or for the storage of materials while permanent buildings are being constructed.

Consul Harold S. Van Buren, of Nice, France, wrote:

There may be a few sheds of wood or detached stables of a temporary character, but not sufficient to form a portion of the statistics.

Consul John C. Covert, of Lyons, stated:

An official in the office of the mayor informed me that there are no wooden buildings in the city except a few old sheds, constructed without permission and permitted to remain, as they are in open fields and of no danger, being some distance from other buildings.

Consul-General Frank H. Mason wrote concerning Berlin, Germany:

The comparative immunity of Berlin from disastrous fires results not from the efficiency of its fire department—although it does promptly and well what work it has to do—but from the absence of wooden houses and the solid, careful construction of all kinds of stone and brick buildings under the rigid scrutiny of the building police.

Other consuls invariably report, "There are no wooden buildings in the city."

The following statement is made in Special Consular Reports, Volume 38, Bureau of Manufactures, Department of Commerce and Labor, in discussing fire insurance in foreign countries:

In Europe the fire insurance laws are remarkable, chiefly because they compel insurance in some countries, while in all cities they prevent great losses by insisting on the erection of only stone and brick buildings. The fire department systems are ridiculously inadequate as compared with those of American cities, yet the net results are better. French law compels insurance against fire not only for the benefit of the owner, but for his neighbor.

In Germany building insurance is compulsory, and in some kingdoms it is a government monopoly. Russia has an elaborate system of central and local government insurance and compels the insurance of all buildings. In some of the Cantons of Switzerland insurance against loss by fire is compulsory.

The fire loss in the cities of some of the countries of Europe is shown in Table 8.

TABLE 8.—*Fire losses in cities of Europe.*

[Statistics gathered by the Bureau of Manufactures.]

Country.	Population of cities.	Fire loss.	Loss per capita.
Austria [a]	193,387	$72,355	$0.37
Russia [a]	2,673,427	3,100,823	1.16
United Kingdom [a]	4,319,816	1,795,750	.42
Belgium [b]	312,987	178,766	.57
Germany [b]	7,446,447	1,832,402	.25
Norway [c]	222,373	207,000	.93
Switzerland [c]	715,712	192,500	.27
France [d]	4,029,116	2,202,744	.55
	19,913,265	9,582,340	.48

[a] Losses for 1904.
[b] Some cities of country report for 1903; others for 1904.
[c] Losses for 1903.
[d] France reports for 1904 with exception of city of Lyons, which is for 1901.

Some time after these statistics were prepared the National Board of Fire Underwriters obtained permission from the State Department to send their own queries to the consular officers in Europe, with the result that figures showing the fire losses in six countries were obtained, some of them for a period of several years. These figures showed the surprisingly low per capita loss of 33 cents for the six countries and are given in Table 9.

TABLE 9.—*Fire losses in six European countries.*

[Statistics gathered by the National Board of Fire Underwriters.]

Country.	Years.	Annual average.	Population, 1901.	Loss per capita.
Austria	1898–1902	$7,601,389	26,150,597	$0.29
Denmark	1901	660,924	2,588,919	.26
France	1900–1904	11,699,275	38,595,500	.30
Germany	1902	27,655,600	56,367,178	.49
Italy	1901–1904	4,112,725	32,449,754	.12
Switzerland	1901–1903	999,364	3,325,023	.30
Average loss per capita				33 cents

EUROPEAN AND AMERICAN FIRE LOSSES COMPARED.

EXCESSIVE AMERICAN FIRE LOSS.

The results obtained indicate that the total annual cost of fires in the United States if buildings were as nearly 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 figures are set forth in Table 10.

TABLE 10.—*Comparison of loss and outlay in the United States on account of fires in 1907 with probable annual loss and expense if buildings were as nearly fireproof as in Europe.*

	Actual loss.		Probable annual loss under European conditions.	
	Total.	Per capita.	Total.	Per capita.
Loss by fire	$215,084,709	.....	$41,000,000	.....
Excess premiums over insurance paid	145,604,362	.....	28,000,000	.....
Annual expense of waterworks chargeable to fire service	28,856,235	.....	6,000,000	.....
Annual expense of fire departments	48,940,845	.....	10,000,000	.....
Annual expense of private fire protection	18,000,000	.....	5,000,000	.....
	456,486,151	$5.34	90,000,000	$1.05
Total loss by fire	215,084,709	2.54	41,000,000	.48
Annual expense of fire protection	241,401,442	2.82	49,000,000	.57

EXCESSIVE PER CAPITA LOSS IN CITIES.

Another comparison, which is perhaps even more interesting as illustrating America's needless waste and Europe's prudence, is given in Table 11, showing the per capita loss in cities of the United States and Europe arranged in classes according to population.

TABLE 11.—*Per capita fire losses in 1907 in American and European cities, classified according to population.*

[Statistics for the United States gathered by the Geological Survey and for Europe by the Bureau of Manufactures.]

Population.	United States.	Europe.
Over 300,000	$2.24	$0.65
100,000 to 300,000	2.14	.37
50,000 to 100,000	2.47	1.67
30,000 to 50,000	3.28	.72
10,000 to 30,000	2.37	.81
Under 10,000	3.47	.....

By comparing American and European cities of the same size the per capita losses shown in Table 12 are found.

TABLE 12.—*Fire losses in American and in European cities of the same size.*

[Statistics gathered by Geological Survey and Bureau of Manufactures. Each of the foreign cities is compared with the American city marked by the same numeral.]

EUROPEAN LOSSES FOR 1904.

City.	Population.	Fire loss.	Loss per capita.
1. Paris, France	2,714,068	$1,266,282	$0.47
2. Frankfort, Germany	324,500	99,492	.31
3. St. Petersburg, Russia	1,500,000	2,128,541	1.42
4. Birmingham, England	550,000	226,506	.41
5. Sheffield, England	426,686	75,989	.18
6. Toulon, France	101,602	55,391	.55
7. Bremen, Germany	203,847	78,372	.38
8. Molenbeck, Belgium	63,678	106,150	1.67
9. Lalken, Belgium	31,121	22,349	.72
10. Etterbeck, Belgium	23,992	19,504	.81

UNITED STATES LOSSES FOR 1907.

1. Chicago, Ill	2,049,185	$3,937,105	$1.43
2. Cincinnati, Ohio	345,230	1,971,217	5.70
3. Philadelphia, Pa	1,441,735	2,093,522	1.45
4. Baltimore, Md	553,669	916,603	1.66
5. Cleveland, Ohio	460,000	515,194	1.12
6. Atlanta, Ga	104,984	225,237	2.15
7. St. Paul, Minn	204,000	522,447	2.56
8. Evansville, Ind	63,957	196,702	3.08
9. Oshkosh, Wis	31,033	80,500	2.59
10. Easton, Pa	25,238	32,073	1.27

EXCESSIVE COST OF FIRE PROTECTION IN THE UNITED STATES.

The average annual cost of maintaining fire departments in European cities and in American cities is shown in Table 13, 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 Table 10, giving 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 these costs 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.

TABLE 13.—*Comparison of annual cost of maintenance of fire departments in European and in American cities.*

City.	Population.	Cost of maintenance.	Cost per capita.
Kiel and suburbs, Germany	171,000	179,002 m.= $42,602	$0.25
Cologne and suburbs, Germany	458,037	509,609 m.= 121,286	.26
Berlin, Germany	1,888,848	2,035,346 m.= 484,412	.26
Breslau, Germany	422,738	465,571 m.= 110,805	.26
London, England	6,580,616	£254,045 =1,238,469	.19
St. Petersburg, Russia	1,313,300	578,503 r. = 295,036	.22
Paris, France	2,714,068	2,925,334 f. = 564,589	.21
Stockholm, Sweden	311,043	269,164 K.= 72,135	.23
Budapest, Austria	723,322	281,544 K.= 57,123	.06
Milan, Italy	491,460	431,253 l. = 83,231	.17
	15,074,432	3,069,688	.20
Cities in United States having population of 100,000 or more	16,883,435	25,764,386	1.53

HOW TO REDUCE FIRE LOSSES.

The enormous waste due to fire may possibly be reduced—

1. By tests and investigations made to determine the relative fire resistance of building materials and the relative rates of heat conductivity of such materials and by the development of systems of construction which will offer the maximum resistance to fire. The tests should have in view the classification of building materials in the order of merit and the possibility of cheapening the cost of construction by using those best suited to the purpose, inasmuch as the cheaper materials are now often not employed through lack of knowledge of their availability.

2. By the dissemination of information regarding the more noninflammable building materials, their strength and durability, the methods of utilizing them in construction, and the availability of the most suitable of these materials at places near the locality at which they are wanted.

3. By the enactment and enforcement of building codes with a view to insuring more fire-resistant and more nearly fireproof construction. In many European cities the erection of wooden buildings is prohibited, and the oversight of brick, stone, steel, and cement construction is such as to diminish the danger from fire due to defective flues, poor electric wiring, and other faults of construction, and to make it unlikely for a fire to spread beyond the building in which it originates.

WASTE OF NATURAL RESOURCES BY FIRE.

Aside from the enormous and unnecessary tax that is paid by the people by reason of fire losses, there is another loss of large consequence to the future of the country—the waste of natural resources due to destruction by fire.

The timber supply of the United States is rapidly approaching exhaustion and, unless means are taken to limit the waste (a great deal of it through fire) and to replenish the supply through reforestation, the timber resources of the country will be exhausted within the next quarter of a century. The known supplies of high-grade iron ore in this country, estimated at more than 4,788,000,000 tons, can not 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 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 underground 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 purposes 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 more 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 wood products and the more easily fabricated and more 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 investigation 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.

Within the last decade the value of the cement manufactures of this country has increased from $9,859,000 to $55,803,000, or nearly sixfold. In the same time the value of the clay products has increased from $74,487,000 to $183,942,000, or has nearly doubled, and that of the building stone has increased from $26,635,000 to $71,106,000, or has nearly trebled. As the Government, through its investigations is determining the strength, durability, and fire-resisting properties of these materials and the more suitable forms for their use, and is disseminating information relative to their comparative cheapness and great permanence, a still greater relative increase in their use may be confidently expected in the near future.

Within the last few years marvelous strides have been made in the substitution of iron and steel for wood as a result of the careful investigations of their properties made by engineers, physicists, and chemists, and the great amount of attention paid to their fabrication by manufacturers and architects. More recently the engineering and technical professions have advanced to a great extent the uses of cement in concrete manufactures. But in a much greater period little has been done toward ascertaining the physical and chemical properties and the best modes of manufacture and use of clay products and stone. Undoubtedly great progress in the use of all these materials may now be reasonably expected with proper encouragement from the Government as an exampler in its method of studying, testing, and using them.

WASTE OF STRUCTURAL MATERIALS OTHER THAN THAT BY FIRE.

The waste of natural mineral resources used in building and engineering construction is of three kinds. That from fire losses has already been mentioned. The other two are (1) that due to improper and wasteful methods of mining and preparing for market, and (2) that due to the use of excessive amounts in structural forms because of ignorance of the strength and durability of the materials.

The large waste of mineral products due to uneconomical and inefficient methods of manufacture, including waste of fuel, as in the burning of cement or of clay products, and in the preparation of coke used in refining iron ores, will be reduced by improvements that will be made in the natural development of the various manufacturing industries concerned.

On account of the waste of structural materials due to lack of knowledge of their strength the present systems of construction are highly expensive, many engineers and architects adopting working stresses for concrete and metal construction from one-fourth to as low as one-eighth the actual working strength of the material. This means that from three to six times the amount of such material that is necessary may be used in structural work. Moreover, materials of superior quality may be little used because of this lack of information as to their properties. The average architect, engineer, or contractor does not take chances in using unfamiliar materials or designs, but confines himself to those which he knows have proved successful.

Most of the information heretofore available concerning the strength and suitability of building materials has been procured by individuals and has been based on insufficient data and tests. The Government, as the largest consumer of these materials, should, as a matter of economy, conduct exhaustive tests of the kinds which have proved so successful under the Forest Service in determining the woods most suitable for each particular use. These tests should be conducted with a view to establishing the physical properties of the materials and to suggesting improved methods of manufacture which may not only prove economical, but which may also improve the quality of the materials in use and extend their life. They should afford information relative to the most fire-resisting and fireproof forms of construction, the former for the prevention of conflagrations due to secondary or exposure fires and the latter for the prevention of the destruction of the building in which the fire may originate. They should also include extended investigations made with a view to prevent the loss of structural materials exposed to the action of salt water, of alkalies in the arid regions, or similar destructive agencies. Not until a better knowledge is had as to the structural material

appropriate for any particular purpose, be it steel, iron, cement manufactures, or clay products, will it be possible to reduce the wasteful consumption.

The investigations in progress by the Geological Survey indicate that smaller quantities of cement-making materials, of gravel and sand suitable for concrete structures, and of clay suitable for making brick will suffice, and also show how construction can be done at least cost. Already, not only in treeless regions, but elsewhere also, the use of such materials is rapidly increasing.

SURVEY PUBLICATIONS ON STRUCTURAL MATERIALS.

The following reports of the Geological Survey relate to structural materials, etc. A copy of any except those that are priced can be had free by applying to the Director, U. S. Geological Survey, Washington, D. C. The others can be obtained by sending price, in cash, to Superintendent of Documents, Government Printing Office, Washington, D. C.

BULLETIN 243. Cement materials and industry of the United States, by E. C. Eckel. 1905. 395 pp., 15 pls. 65c.

BULLETIN 249. Limestones of southwestern Pennsylvania, by F. G. Clapp. 1905. 52 pp., 7 pls.

BULLETIN 260. Contributions to economic geology, 1904. 1905. Contains several papers on structural materials. 40c.

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MINERAL RESOURCES U. S. for 1901 (70c), 1902, 1903 (70c), 1904, 1905 ($1), 1906 (50c), 1907, pt. 2 ($1), and 1908, pt. 2. Contains statistics of production of building stones, cement, and clay. The volume for 1906 contains Advances in cement technology, by E. C. Eckel, pp. 897–905.

PROFESSIONAL PAPER 11. The clays of the United States east of the Mississippi River, by Heinrich Ries. 1903. 298 pp. 40c.

SIXTEENTH ANNUAL REPORT, pt. 4. Technology of the clay industry, by Heinrich Ries, pp. 523–575, 4 pls. 1895. $1.20.

SEVENTEENTH ANNUAL REPORT, pt. 1, *g*. 1896. Glacial brick clays of Rhode Island and southeastern Massachusetts, by N. S. Shaler, J. B. Woodworth, and C. F. Marbut, pp. 951–1004, pls. lxi–lxii.

NINETEENTH ANNUAL REPORT, pt. 6 (continued). 1898. Kaolins and fire clays of Europe, by Heinrich Ries, pp. 377–400.

TWENTY-SECOND ANNUAL REPORT, pt. 3, *n*. 1901. Portland cement industry in Michigan, by I. C. Russell, pp. 629–685, pls. xliv–xlvi.

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