THE BREWSTER HANDBOOKS

MILL & FACTORY INSPECTION

WITH NOTES ON THE HYDRAULICS OF AUTOMATIC SPRINKLER PROTECTION

By A. IRVING BREWSTER

RETURN TO A. D. RISTEEN, ENGINEER
ENGINEERING AND INSPECTION DIVISION
THE "ESTY" Automatic Sprinkler gives complete protection against serious fires and loss of life, and reduces Fire Insurance Cost. The "ESTY" is a pioneer in automatic firefighting and has an unbroken record for efficient operation.

Let us tell you what users of The "ESTY" say about its value.

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THE H. G. VOGEL COMPANY
12-14 Walker St., New York
THE PRINCIPLES
OF
MILL AND FACTORY INSPECTION
For Fire Insurance Purposes
With Notes on the Hydraulics of
AUTOMATIC SPRINKLER PROTECTION

By A. IRVING BREWSTER
Editor, "Insurance Engineering", 1903-1912
Associate Editor, "The Insurance Field", 1912-1915

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A. D. RISTEEN, ENGINEER,
ENGINEERING AND INSPECTION DIVISION.

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MILL AND FACTORY INSPECTION

The purpose of examining manufacturing plants ("special hazards") and other important "risks" for fire insurance companies is to gather information that will enable them to judge how much the construction and contents of buildings are liable to favor the spread of fire, or retard it; what the chances are of fire originating within buildings from the uses made of them; the value of appliances, public and private, provided for extinguishing fire; and the likelihood of fire communicating from one room to another or from one building to another belonging to the same plant ("mutual exposure of buildings"), and the possibility or probability of fire in any neighboring factory or other "exposure" communicating to the one under consideration or to several others ("the conflagration hazard").

The vast work to be done by fire insurance inspectors, on the one hand, and by fire protection engineers, on the other, in the United States and its possessions, Porto Rico, Hawaii and Alaska, is plainly indicated by the phenomenal growth of the number of mills and factories, and other classes of property such as department stores, theaters, motion-picture playhouses, motion-picture film
factories, garages, hotels, office buildings, public buildings, grain elevators, railroad terminals, warehouses, public stores, etc., to be insured and protected against serious damage or destruction by fire.

A greater work, for fire protection engineers, is the devising of ways and means for preventing the burning of large numbers of buildings by general fires or conflagrations.

The most convincing proof of the vastness of this work is found in the statistics compiled by the Bureau of the Census, Department of Commerce and Labor. In 1909 there were in Continental United States a total of 268,491 industrial establishments, 939 in Porto Rico, 500 in Hawaii and 152 in Alaska, making a grand total of 270,082.

In those 270,082 industrial establishments was invested a total capital of $18,490,749,206, the total operating expense for the year 1909 was $18,526,435,292, and the total value of the products for the same year was $20,767,545,597. Only about one-half of one per cent. of the products for that year was contributed by Porto Rico, Hawaii and Alaska. The leading industries of Porto Rico are sugar and tobacco products and the preparation of coffee for market. The principal industry of Hawaii is the manufacture of sugar. Canning and curing fish are the most important industries in Alaska.

Thirteen metropolitan districts in Continental United States claim the attention of students of fire insurance
inspecting and fire protection engineering on account of their importance as manufacturing centers. The total value of their products in 1909 was $8,658,267,349, or 41.9 per cent. of the total for the entire country. In these metropolitan districts is found the greatest congestion of insurable values in property (buildings, machinery, raw materials and finished products) exposed to destruction by general fires or conflagrations. These districts are as follows:

**New York City District.**—This district includes Greater New York, (Bronx, Kings, New York, Queens and Richmond counties) and Nassau and Westchester counties in New York State; and Bergen, Essex, Hudson, Middlesex, Passaic and Union counties in New Jersey.

In the New York City district in 1909 there were 31,782 industrial establishments, employing 948,706 persons, and having a total capital of $2,117,433,047. The total value of their products in 1909 was $2,970,143,382.

**Chicago District.**—This district includes Chicago and certain townships in Cook county, Illinois, and Lake county, Indiana.

In the Chicago district in 1909 there were 10,202 industrial establishments, employing 393,859 persons, and having a total capital of $1,144,002,902. The total value of their products in 1909 was $1,408,779,818.

**Philadelphia District.**—This district includes the city of Philadelphia, and Bucks, Chester, Delaware and Mont-
gomery counties in Pennsylvania; and Burlington, Camden and Gloucester counties in New Jersey.

In the Philadelphia district in 1909 there were 9,568 industrial establishments, employing 358,218 persons, and having a total capital of $863,968,450. The total value of their products in 1909 was $911,014,010.

Pittsburgh District.—This district includes the city of Greater Pittsburgh and the balance of Allegheny county and certain places in Washington and Westmoreland counties in Pennsylvania.

In the Pittsburgh district in 1909 there were 2,369 industrial establishments, employing 163,258 persons, and having a total capital of $642,527,046. The total value of their products in 1909 was $578,815,493.

Boston District.—This district includes the city of Boston and the balance of Suffolk county, and Essex, Middlesex and Norfolk counties in Massachusetts.

In the Boston district in 1909 there were 5,389 industrial establishments, employing 214,641 persons, and having a total capital of $444,558,420. The total value of their products in 1909 was $564,054,506.

St. Louis District.—This district includes St. Louis and the remainder of St. Louis county in Missouri, and St. Clair and Madison counties in Illinois.

In the St. Louis district in 1909 there were 2,951 industrial establishments, employing 126,453 persons, and having a total capital of $356,356,256. The total value
of their products in 1909 was $430,170,244.

_Cleveland District._—This district includes Cleveland and the remainder of Cuyahoga county in Ohio.

In the Cleveland district in 1909 there were 2,230 industrial establishments, employing 103,709 persons, and having a total capital of $236,911,140. The total value of their products in 1909 was $281,992,131.

_Buffalo District._—This district includes Buffalo and the remainder of Erie county and Niagara county in New York.

In the Buffalo district in 1909 there were 1,964 industrial establishments, employing 75,086 persons, and having a total capital of $280,052,887. The total value of their products in 1909 was $279,852,346.

_Detroit District._—This district includes Detroit and the remainder of Wayne county in Michigan.

In the Detroit district in 1909 there were 2,104 industrial establishments, employing 101,482 persons, and having a total capital of $210,401,992. The total value of their products in 1909 was $268,899,761.

_Cincinnati District._—This district includes Cincinnati and the remainder of Hamilton county in Ohio and seven magisterial districts in Campbell and Kenton counties in Kentucky.

In the Cincinnati district in 1909 there were 2,827 industrial establishments, employing 95,571 persons, and
having a total capital of $212,555,469. The total value of their products in 1909 was $260,399,619.

Baltimore District.—This district includes Baltimore and the remainder of Baltimore county and one district in Anne Arundel county in Maryland.

In the Baltimore district in 1909 there were 2,668 industrial establishments, employing 94,954 persons, and having a total capital of $199,735,181. The total value of their products in 1909 was $260,213,324.

Minneapolis-St. Paul District.—This district includes Minneapolis and two villages in Hennepin county, and St. Paul and two small places in Dakota county in Minnesota.

In the Minneapolis-St. Paul district in 1909 there were 1,844 industrial establishments, employing 59,920 persons, and having a total capital of $160,628,295. The total value of their products in 1909 was $244,339,598.

San Francisco-Oakland District.—This district includes San Francisco and Oakland and other portions of Alameda, Contra Costa, Marin and San Mateo counties in California.

In the San Francisco-Oakland district in 1909 there were 2,539 industrial establishments, employing 53,177 persons, and having a total capital of $187,701,402. The total value of their products in 1909 was $199,593,117.

Industrial Groups.—For the purpose of the census the industries of the United States were divided into thirteen general groups, (1) food and kindred products, (2) tex-
tiles, (3) iron and steel and their products, (4) lumber and its manufactures, (5) leather and its finished products, (6) paper and printing, (7) liquors and beverages, (8) chemicals and allied products, (9) stone, clay, and glass products, (10) metals and metal products, other than iron and steel, (11) tobacco manufactures, (12) vehicles for land transportation, and (13) railroad repair shops.

*Characteristics of Industries.*—There are certain characteristics about each of these thirteen general groups of industries which are of especial interest to fire insurance inspectors and fire protection engineers, such as (1) value of products for one year, (2) cost of raw materials for the same period, (3) the value added to the raw materials by manufacturing processes, (4) the number of establishments in each industry, and (5) the average number of wage earners. The rank of each of the thirteen general groups mentioned above in the year 1909 under these five headings was as follows:

1. **Value of Products.**
   1. Food and kindred products .............. $3,937,617,891
   2. Iron and steel and their products .... 3,163,126,293
   3. Textiles ........................................ 3,054,708,084
   4. Lumber and its manufactures .......... 1,582,522,263
   5. Chemicals and allied products ....... 1,430,901,954
   6. Metals and metal products other than iron and steel .............. 1,238,251,401
### 10 M I L L A N D F A C T O R Y I N S P E C T I O N

<table>
<thead>
<tr>
<th>No.</th>
<th>Industry</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>7.</td>
<td>Paper and printing</td>
<td>1,179,285,247</td>
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<td>8.</td>
<td>Leather and its finished products</td>
<td>992,713,322</td>
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<td>9.</td>
<td>Liquors and beverages</td>
<td>674,311,051</td>
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<td>10.</td>
<td>Vehicles for land transportation</td>
<td>561,763,289</td>
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<td>11.</td>
<td>Stone, clay and glass products</td>
<td>531,736,831</td>
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<td>12.</td>
<td>Railroad repair shops</td>
<td>437,563,288</td>
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<tr>
<td>13.</td>
<td>Tobacco manufactures</td>
<td>416,695,104</td>
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#### 2. Cost of Materials.

<table>
<thead>
<tr>
<th>No.</th>
<th>Industry</th>
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<tbody>
<tr>
<td>1.</td>
<td>Food and kindred products</td>
<td>$3,187,803,080</td>
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<tr>
<td>2.</td>
<td>Iron and steel and their products</td>
<td>1,802,105,826</td>
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<tr>
<td>3.</td>
<td>Textiles</td>
<td>1,741,987,395</td>
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<td>4.</td>
<td>Metals and metal products other than iron and steel</td>
<td>891,014,733</td>
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<tr>
<td>5.</td>
<td>Chemicals and allied products</td>
<td>867,019,526</td>
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<tr>
<td>6.</td>
<td>Lumber and its manufactures</td>
<td>714,573,711</td>
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<tr>
<td>7.</td>
<td>Leather and its finished products</td>
<td>669,874,518</td>
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<tr>
<td>8.</td>
<td>Paper and printing</td>
<td>451,238,634</td>
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<tr>
<td>9.</td>
<td>Vehicles for land transportation</td>
<td>306,536,675</td>
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<tr>
<td>10.</td>
<td>Railroad repair shops</td>
<td>214,581,311</td>
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<tr>
<td>11.</td>
<td>Liquors and beverages</td>
<td>186,127,887</td>
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<tr>
<td>12.</td>
<td>Stone, clay and glass products</td>
<td>183,791,550</td>
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<tr>
<td>13.</td>
<td>Tobacco manufactures</td>
<td>177,185,621</td>
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#### 3. Value Added by Manufacture.

<table>
<thead>
<tr>
<th>No.</th>
<th>Industry</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Iron and steel and their products</td>
<td>$1,361,020,467</td>
</tr>
<tr>
<td>2.</td>
<td>Textiles</td>
<td>1,312,720,689</td>
</tr>
</tbody>
</table>
3. Lumber and its manufactures........ 867,948,552
4. Food and kindred products........... 749,814,811
5. Paper and printing.................. 728,046,613
6. Chemicals and allied products......... 563,882,428
7. Liquors and beverages................ 488,183,164
8. Stone, clay and glass products........ 347,945,281
9. Metals and metal products other than iron and steel........ 347,236,668
10. Leather and its finished products.... 322,838,804
11. Vehicles for land transportation...... 255,226,614
12. Tobacco manufactures............... 239,509,483
13. Railroad repair shops................ 222,981,977

4. Number of Establishments.
1. Food and kindred products............ 55,364
2. Lumber and its manufactures........... 48,533
3. Paper and printing.................. 34,828
4. Textiles ................................ 21,695
5. Iron and steel and their products...... 17,289
6. Stone, clay and glass products........ 16,168
7. Tobacco manufactures................ 15,822
8. Chemicals and allied products......... 11,745
9. Metals and metal products other than iron and steel........ 8,750
10. Liquors and beverages................ 7,347
11. Vehicles for land transportation........ 6,562
12. Leather and its finished products............ 5,728
13. Railroad repair shops.......................... 1,686

### 5. Number of Wage Earners.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Number of Wage Earners</th>
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</thead>
<tbody>
<tr>
<td>Textiles</td>
<td>1,437,258</td>
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<tr>
<td>Iron and steel and their products</td>
<td>1,025,044</td>
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<tr>
<td>Lumber and its manufactures</td>
<td>907,514</td>
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<tr>
<td>Paper and printing</td>
<td>415,990</td>
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<tr>
<td>Food and kindred products</td>
<td>411,575</td>
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<tr>
<td>Stone, clay and glass products</td>
<td>342,827</td>
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<tr>
<td>Leather and its finished products</td>
<td>309,766</td>
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<tr>
<td>Railroad repair shops</td>
<td>304,592</td>
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<tr>
<td>Metals and metal products other than iron and steel</td>
<td>248,785</td>
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<tr>
<td>Chemicals and allied products</td>
<td>237,988</td>
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<tr>
<td>Vehicles for land transportation</td>
<td>202,719</td>
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<tr>
<td>Tobacco manufactures</td>
<td>166,810</td>
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<tr>
<td>Liquors and beverages</td>
<td>77,827</td>
</tr>
</tbody>
</table>

The rank of the ten leading States according to the value of manufactured products in 1909 was (1) New York, (2) Pennsylvania, (3) Illinois, (4) Massachusetts, (5) Ohio, (6) New Jersey, (7) Michigan, (8) Wisconsin, (9) Indiana, and (10) Missouri. The States yielding the smallest values in manufactured products were North Dakota, South Dakota, Nevada, New Mexico and Wyoming.

*Leading Industries.*—All of the States are characterized by certain industries which predominate, and in some instances they are practically confined to one State. The
five leading industries of each State in 1909, measured by the value of their products, were:

_Alabama._—Lumber and timber products; cotton goods, including cotton small wares; iron and steel, blast furnaces; foundry and machine shop products; cottonseed oil and cake.

_Arizona._—Copper smelting and refining; cars and general shop construction and repairs by steam railroad companies; lumber and timber products; flour mill and grist mill products; printing and publishing.

_Arkansas._—Lumber and timber products; cottonseed oil and cake; flour mill and grist mill products; cars and general shop construction and repairs by steam railroad companies; printing and publishing.

_California._—Lumber and timber products; lead smelting and refining; slaughtering and meat packing; canning and preserving; foundry and machine shop products.

_Colorado._—Lead smelting and refining; beet sugar; iron and steel, steel works and rolling mills; slaughtering and meat packing; flour mill and grist mill products.

_Connecticut._—Brass and bronze products; foundry and machine shop products; cotton goods, including cotton small wares; silk and silk goods, including throwsters; fire arms and ammunition.

_Delaware._—Tanned, curried and finished leather; foundry and machine shop products; steam railroad cars, not including operations of railroad companies; cars and
general shop construction and repairs by steam railroad companies; dyeing and finishing textiles.

District of Columbia.—Printing and publishing; bread and other bakery products; gas for illuminating and heating; slaughtering and meat packing; malt liquors.

Florida.—Tobacco manufactures; lumber and timber products; turpentine and rosin; fertilizers; printing and publishing.

Georgia.—Cotton goods, including cotton small wares; lumber and timber products; cottonseed oil and cake; fertilizers; flour mill and grist mill products.

Idaho.—Lumber and timber products; flour mill and grist mill products; beet sugar; cars and general shop construction and repairs by steam railroad companies; printing and publishing.

Illinois.—Slaughtering and meat packing; foundry and machine shop products; men’s clothing, including shirts; printing and publishing; iron and steel, steel works and rolling mills.

Indiana.—Slaughtering and meat packing; flour mill and grist mill products; foundry and machine shop products; iron and steel, steel works and rolling mills; distilled liquors.

Iowa.—Slaughtering and meat packing; butter, cheese and condensed milk; foundry and machine shop products; flour mill and grist mill products; lumber and timber products.
Kansas.—Slaughtering and meat packing; flour mill and grist mill products; cars and general shop construction and repairs by steam railroad companies; zinc smelting and refining; printing and publishing.

Kentucky.—Distilled liquors; flour mill and grist mill products; lumber and timber products; tobacco manufactures; foundry and machine shop products.

Louisiana.—Lumber and timber products; sugar refining, not including beet sugar; sugar and molasses; cottonseed oil and cake; rice cleaning and polishing.

Maine.—Paper and wood pulp; lumber and timber products; cotton goods, including cotton small wares; woolen, worsted and felt goods and wool hats; boots and shoes, including cut stock and findings.

Maryland.—Men's clothing, including shirts; copper smelting and refining; copper, tin and sheet-iron products; canning and preserving; slaughtering and meat packing.

Massachusetts.—Boots and shoes, including cut stock and findings; cotton goods, including cotton small wares; woolen, worsted and felt goods and wool hats; foundry and machine shop products; printing and publishing.

Michigan.—Automobiles, including bodies and parts; lumber and timber products; foundry and machine shop products; flour mill and grist mill products; furniture and refrigerators.

Minnesota.—Flour mill and grist mill products; lumber and timber products; slaughtering and meat packing;
butter, cheese and condensed milk; printing and publishing.

Mississippi.—Lumber and timber products; cottonseed oil and cake; cars and general shop construction and repairs by steam railroad companies; cotton goods, including cotton small wares; fertilizers.

Missouri.—Slaughtering and meat packing; boots and shoes, including cut stock and findings; flour mill and grist mill products; tobacco manufactures; printing and publishing.

Montana.—Copper smelting and refining; lumber and timber products; lead smelting and refining; cars and general shop construction and repairs by steam railroad companies; malt liquors.

Nebraska.—Slaughtering and meat packing; lead smelting and refining; flour mill and grist mill products; butter, cheese and condensed milk; printing and publishing.

Nevada.—Copper smelting and refining; cars and general shop construction and repairs by steam railroad companies; slaughtering and meat packing; flour mill and grist mill products; printing and publishing.

New Hampshire.—Boots and shoes, including cut stock and findings; cotton goods, including cotton small wares; woolen, worsted and felt goods, and wool hats; lumber and timber products; paper and wood pulp.

New Jersey.—Copper smelting and refining; petroleum refining; silk and silk goods, including throwsters; foundry
and machine shop products; slaughtering and meat packing.

**New Mexico.**—Cars and general shop construction and repairs by steam railroad companies; lumber and timber products; coke; printing and publishing; flour mill and grist mill products.

**New York.**—Women's clothing; men's clothing, including shirts; printing and publishing; foundry and machine shop products; slaughtering and meat packing.

**North Carolina.**—Cotton goods, including cotton small wares; tobacco manufactures; lumber and timber products; cottonseed oil and cake; flour mill and grist mill products.

**North Dakota.**—Flour and grist mill products; printing and publishing; butter, cheese and condensed milk; leather goods; cars and general shop construction and repairs by steam railroad companies.

**Ohio.**—Iron and steel, steel works and rolling mills; foundry and machine shop products; iron and steel, blast furnaces; rubber goods; slaughtering and meat packing.

**Oklahoma.**—Flour mill and grist mill products; cottonseed oil and cake; lumber and timber products; printing and publishing; zinc smelting and refining.

**Oregon.**—Lumber and timber products; flour mill and grist mill products; slaughtering and meat packing; printing and publishing; butter, cheese and condensed milk.

**Pennsylvania.**—Iron and steel, steel works and rolling mills; foundry and machine shop products; iron and steel,
blast furnaces; tanned, curried and finished leather; woolen, worsted and felt goods, and wool hats.

*Rhode Island.*—Woolen, worsted and felt goods, and wool hats; cotton goods, including cotton small wares; jewelry; foundry and machine shop products; dyeing and finishing textiles.

*South Carolina.*—Cotton goods, including cotton small wares; lumber and timber products; cottonseed oil and cake; fertilizers; printing and publishing.

*South Dakota.*—Flour mill and grist mill products; butter, cheese and condensed milk; printing and publishing; bread and other bakery products; lumber and timber products.

*Tennessee.*—Lumber and timber products; flour mill and grist mill products; foundry and machine shop products; printing and publishing; cars and general shop construction and repairs by steam railroad companies.

*Texas.*—Slaughtering and meat packing; flour mill and grist mill products; lumber and timber products; cottonseed oil and cake; petroleum refining.

*Utah.*—Copper smelting and refining; lead smelting and refining; beet sugar; flour mill and grist mill products; cars and general shop construction and repairs by steam railroad companies.

*Vermont.*—Marble and stone work; lumber and timber products; butter, cheese and condensed milk; woolen,
worsted and felt goods, and wool hats; flour mill and grist mill products.

*Virginia.*—Lumber and timber products; tobacco manufactures; flour mill and grist mill products; cars and general shop construction and repairs by steam railroad companies; tanned, curried and finished leather.

*Washington.*—Lumber and timber products; flour mill and grist mill products; slaughtering and meat packing; canning and preserving; printing and publishing.

*West Virginia.*—Lumber and timber products; iron and steel, steel works and rolling mills; tanned, curried and finished leather; tin plate and terneplate; glass.

*Wisconsin.*—Lumber and timber products; foundry and machine shop products; butter, cheese and condensed milk; tanned, curried and finished leather; malt liquors.

*Wyoming.*—Cars and general shop construction and repairs by steam railroad companies; lumber and timber products; flour mill and grist mill products; printing and publishing; iron and steel, steel works and rolling mills.
ANALYSIS OF INSPECTION REPORTS

INSPECTIONS of manufacturing plants and other important risks are made by fire insurance companies jointly through organizations called bureaus, by private concerns and by fire insurance companies individually. The first bureau (the New England Bureau of United Inspection, Boston, Mass.), was organized about 1888 and the following year the Middle States Inspection Bureau, New York City, was formed. Sending one inspector to a risk to represent a large number of fire insurance companies who had issued policies on it proved economical both to the companies and to the insured, and avoided a conflict of recommendations for improvements offered by the inspectors of different companies. Large companies, however, have found it advisable to maintain a staff of inspectors of their own, in order to give the best service to their policy-holders. Fire insurance agents and brokers have also found it profitable to have their own inspectors.

The more important risks are inspected once a year, or oftener. Those equipped with automatic sprinklers (Improved Risks) are usually inspected four times a year. The first report, called an “original,” gives in detail the
information desired by fire insurance companies about the occupancy, manufacturing processes ("special" fire hazards), construction of buildings, occupancy and construction of "exposing" buildings, ordinary fire hazards, special fire hazards, private fire protection, public fire protection, fire record, etc. Subsequent reports, called re-inspections, give all the important changes since the date of the original report. When a risk has been materially enlarged since the original inspection, it may be advisable to write up a new original report for the convenience of the companies (this saves them the trouble and annoyance of having to read two or more reports on the same risk). When a risk has been re-built after a fire, a new original report is required. To make an intelligent re-inspection of any risk, it is necessary to first study all existing reports.

Making re-inspections is just as important as original inspections. Adding new buildings and machinery increase the value that may be destroyed by fire. Introducing some new process may mean a new fire hazard. A change in the occupancy of any floor may adversely affect the danger of a loss extending beyond the floor where a fire originates, as storing in a basement finished goods that are susceptible to damage by water used in extinguishing a fire on one of the upper floors. Cutting a doorway (or any other opening) in a brick wall that was blank before, and not properly protecting the new doorway, can easily result in a larger fire loss than was possible with a blank brick
wall separating two buildings, or sections. Experiments with new processes employing combustible materials constitute a very important change in the occupancy of any plant and the fullest information should be given in a report, if obtainable.

"Fireproof" Construction.—This name applied to a building ought to mean a building that cannot be destroyed by fire, but such a building is unknown. A better name is "fire-resistive." The name "fireproof building," strictly applied, usually means a building having a structural steel frame, with non-combustible (hollow terra cotta blocks, or reinforced concrete) floors, partitions and roof; or a building constructed wholly of reinforced concrete. Although the steel frame of a so-called fireproof building will not burn, it is readily affected by heat and when exposed to the heat of a fire it will lose its shape and allow a building to collapse. All of the steelwork in a building of this type of construction must be completely protected with some fireproofing material, such as hollow terra cotta blocks, concrete, etc.

A building of co-called "fireproof" construction is no protection against the burning of combustible contents. A fire burning inside of any building, if not promptly extinguished, will usually destroy everything inside of the building that will burn, or melt.

Unprotected openings in floors, for stairs, elevators, etc., and in walls, are just as objectionable in a building
of so-called "fireproof" construction, as in any other type of building, because they help fire to spread.

The nearest approach to fireproof construction is a building in which a fire can readily be confined to the room or floor, where it originates.

Probably the ideal building, as regards safety from serious fire losses, is one constructed wholly of fire-resistive materials and completely protected by automatic sprinklers.

"Slow-Burning" Construction.—Another name for this type of building is "mill" construction. Buildings of standard "slow-burning" construction have no concealed spaces in the floors, partitions or roof, and there are no unprotected openings in the floors to help fire to spread. All stairs and elevators are enclosed in brick towers, and the openings to the different floors are protected with fire doors. The term "slow-burning" refers to the heavy solid wooden floors, beams and columns found in buildings of standard construction. The wood used for the floors and the beams and the columns supporting the floors, will burn up if a fire is not extinguished, but on account of the thickness of the floors and the sizes of the floor beams and columns the wood will burn very slowly.

This type of construction is instantly recognized, on entering a building, by the heavy wooden columns and the heavy wooden beams on the ceilings. The spaces on the ceilings between the floor beams are called "bays."

The walls of buildings of this type are usually of brick
and they are frequently found braced on the outside by "buttresses" of brick.

The success of this type of building construction depends chiefly on all of the floors being entirely free from openings for stairs, elevators, etc., and even smaller openings for belting or shafting. The best results are obtained when these buildings are completely protected by automatic sprinklers.

In recent years the scarcity of timber of the necessary dimensions has led to the use of rolled steel floor beams in buildings of slow-burning" construction. When a building is completely protected by automatic sprinklers, these steel floor beams may safely be left unprotected.

"Joisted" Construction.—The term "joisted" construction refers to buildings having floors of single, or double, thicknesses of wood laid on the top edges of wooden joists of different sizes. These buildings usually have roofs and partitions of the same type of construction. When the underside of the floor joists is covered with strips of wood, or some other material, to make a smooth ceiling, "concealed" spaces are formed between the ceiling and the floor above it. Concealed spaces may also exist under roofs of this type of construction when the underside of the roof joists (or "rafters," or "purlines") is covered to make a smooth ceiling. Concealed spaces always exist in partitions of this type of construction and may extend for the full height of a building.
"MILL" OR "SLOW-BURNING" CONSTRUCTION

Isometric view of a 4-story building of "mill" or "slow-burning" construction, with brick walls, heavy wooden floors free from openings, stairs and elevator enclosed in a brick tower having doorways protected by fire doors, and divided into two sections by a blank brick wall.
The covering on the underside of floor joists, forming a smooth ceiling, is also called "sheathing."

When the underside of the floor joists has been left uncovered, the ceiling is called "open joisted."

The "concealed spaces" in buildings of "joisted" construction are objectionable because fire can start in them, or get into them, and thus be out of the reach of water thrown from fire pails, or through lines of hose, or from the streams from chemical extinguishers. Fires in concealed spaces are also out of reach of water thrown by automatic sprinklers (see Automatic Sprinklers).

Buildings of "joisted" construction may be constructed entirely of wood, or they may have brick walls and a joisted roof covered on top with sheet tin. Whether the walls are of wood, or of brick, the "joisted" interior (floors and partitions) is quickly destroyed by fire.

Original inspection reports give full details and cover the name of tenant or tenants; location of risk; ownership of buildings; ownership of machinery; number of hands and hours employed; operative and idle seasons peculiar to the industry or the occupancy; goods made or sold; raw stock; processes; machinery; location of largest values; construction of building or buildings; general construction, height, character and proximity of "exposing" buildings or risks; common fire hazards; special fire hazards; administration of premises; private fire protection; public fire protection; fire record of the risk; prominent
"MILL" OR "SLOW-BURNING" CONSTRUCTION

Cross-section view of a 4-story building of "mill" or "slow-burning" construction, showing the tower for stairway and elevator, general floor construction, etc. (See also isometric view on Page 25.)
desirable features; prominent undesirable features; recommendations (essential and desirable) for improvements, and a summary.

**Buildings.**—The points about buildings to be covered by reports are the age and condition of repair, dimensions, story height, walls, roof and roof supports, superstructures, cornices, skylights or ventilators, floors and floor supports, finish of walls and ceilings, all openings through floors such as stairs, elevators, well-holes and hatchways, belt-holes, chutes, etc., partitions and firewalls; and the occupancy of each floor. When a brick or stone building is more than two stories high, the thickness of walls at each floor should be given.

Sometimes a building is found being used for a heavier purpose than it was intended to serve. This means that the adaptability of buildings to the uses made of them should be carefully considered. A business requiring the use of heavy vibrating machinery may be found in a building designed for a lighter purpose, resulting in the weakening of the floor supports and the walls. Extreme cases of this kind have been the conversion of office buildings into manufacturing buildings and the placing of heavy machinery on the upper floors, thus putting upon them considerably more load than they were built to carry. This has caused the collapse of buildings from small fires. A mill might be found in use for a business that would permit of clean floors and yet they would be soaked with oil
PREVENTION OF WATER DAMAGE

Section and plan of scuppers used in buildings of "mill" or "slow-burning" construction, for draining water (thrown on a fire by automatic sprinklers, hose streams, etc.) from each floor, to prevent unnecessary water damage, instead of allowing the water to run down the stairways, etc. The floors are water-tight.
from a former occupancy (where high speed machinery had stood, or where some process requiring the use of oils had been carried on, etc.). Two radical changes in occupancy on record are the changing of a malt house into a wool scouring establishment and the altering of a match factory into a handkerchief factory.

The age of a building may account for its condition of repair—it may be so old that repairs won’t last. Or if repairs are not kept up it may be an indication that the profits of the business do not warrant the expense. Rapid deterioration of buildings might bring values below the insurance carried. Vacant buildings or unused portions may mean that the plant is larger than the needs of the business and might be neglected, proving a menace to the active portions.

In the larger cities the thickness of walls is regulated by law. Light construction makes disastrous fires possible; and light frame construction makes a quick fire, not infrequently a total loss. Walls, ceilings, floors, roofs and cornices should be free from concealed spaces. Such spaces allow fire to burn unnoticed and are hard to reach with water. A wood box cornice continuous with that of another building has permitted fire to crawl from one building to the next and feed it at the same time. Shingle roofs take fire readily from flying sparks. Mansard or French roofs and blind attics are objectionable because in most cases they amount to concealed spaces. Flat thin
glass skylights should be protected with wire mesh screens (made removable so as to permit of cleaning the glass) raised several inches above the glass, to prevent flying embers from a neighboring fire breaking through the thin glass and setting fire to combustible material inside a building. Skylights made from wire-glass, or from translucent fibre, may not require such protection under ordinary conditions.

Floors should be free from openings through them, such as stairs, elevator wells, etc., so a draught cannot spread fire from one floor to another. If there are any such openings in the floors they should be properly trapped or enclosed. This is especially important in buildings protected by automatic sprinklers, as otherwise heat from a fire on one of the lower floors may ascend through openings in the floor above and open sprinklers where there is no fire, meaning unnecessary water damage.

It is preferable to enclose all elevators, stairs, belts, pipes, shafting and vents that pierce floors in towers having brick walls, or reinforced concrete walls, of standard thickness, and all openings therein should be protected by standard automatic self-closing fire doors. The roofs over all enclosed elevators should be made of fire-resistive materials, with a standard skylight, covered above and below with strong wire netting. Wireglass should not be used over elevator enclosures. When the glass in a skylight over an elevator enclosure is thin, it may be easily broken
by firemen and the smoke from a fire vented through the elevator enclosure to the outside of the building. Wire netting protection will prevent embers from a fire in another building breaking the thin glass.

Joisted construction of floors should be avoided; concealed spaces are formed by sheathing the lower edges, and while the open joists are preferable, yet only one side of the joists can be reached with water from the one stream of hose while the other side is burning and automatic sprinklers cannot do as effective work under such ceilings as smooth ones. Heavy wooden floor supports are better than iron ones because they will burn slowly and not warp or twist out of shape. Floors, walls and ceilings should be free from any oil finish, as this only helps fire to spread rapidly and causes dry rot in wood that has not been thoroughly seasoned—it is better to leave the pores of the wood open.

The only way to prevent fire from spreading is to confine it where it originates. It is important to state fully how a room and how a building communicates with other rooms and other buildings. If buildings adjoin and communicate freely with one another, or are built close together ("compact construction"), they are liable to be subject to one fire. Frame buildings so grouped, and by themselves, are always so. With brick buildings a plant may be divided into "fire sections" by heavy walls and by protecting all openings in these walls (doorways, windows, holes for
DANGER OF UNPROTECTED WINDOWS

A fire started at night in the lower building shown in the picture, burned out the three upper stories of this building and destroyed a section of the roof; and also spread to the two higher buildings through unprotected windows in the side wall of one and through windows in a light-shaft between it and the next one. The building in which the fire originated was of "joisted" construction and extended from street to street (see plan on Page 35). The depth of the building and the location of the fire made the fire difficult to reach with hose streams from the street.
shafting, etc.), with doors or shutters made of seasoned wood double (or treble) battenéd and properly covered with lock-jointed tin after the manner of tinning a roof (for specifications see the standards of the National Board of Fire Underwriters).

A group of frame buildings may also be "cut up" in the same manner by providing brick division walls with properly protected openings. All such division walls should project beyond the sides of buildings (and completely through cornices) and above the roof lines, parapeted in the latter instance.

**Defects in Buildings.**—Insurance inspectors should be on the lookout constantly for such defects in buildings as the following, and urge property owners, when reasonable and practicable, to remedy them in accordance with the best standards:

- Lightly built chimneys and flues with insufficient air space.
- Lack of protection against exposures.
- Large floor areas (unsprinkled).
- Excessive height of non-fireproof buildings.
- Light brick construction, and light frame construction.
- Concealed spaces.
- Joisted construction, and heavily timbered roofs.
- Worn condition, or lack of repairs.
- Vacant and unused portions.
PLAN OF 623 BROADWAY AND CONTIGUOUS BUILDINGS
SHOWING FLOOR OPENINGS, STANDPIPES AND FIRE SHUTTERS
(See Report on Fire of March 27, 1912)

DANGER OF UNPROTECTED WINDOWS
Plan of the buildings shown on Page 33, showing the congestion of property found in the business districts of many American cities. (A good example of an insurance map used by all fire insurance companies.)
Compact grouping of buildings with unprotected communications, and rambling construction.
   Shingle roofs.
   Unprotected openings through floors.
   Oily floors, and oil-finished surfaces.
   Heavily loaded upper floors.
   Upper floors of buildings suspended from roof trusses.
   Unprotected structural members of buildings.
   Unprotected thin-glass skylights.
   Frame superstructures on brick buildings, or extensive advertising signs of combustible material.
   Multiplicity of tenants.

Exposures.—When two buildings are within about 100 feet of each other they are said to “expose each other.” In other words, fire starting in one of two such buildings may communicate to the other under favorable circumstances. The compactness of plants consisting of several buildings has already been referred to. This is “mutual exposure,” as differing from “exposure” to fire in some nearby building not a part of the plant under consideration. The worst examples of this feature are found in the congested districts of large cities, where save for the prompt action of first-class public fire departments and the intervention of Providence the losses from conflagration fires would amount to considerably more than they do now.

Exposures deserve very nearly as much attention as the particular establishments under examination. If the risk
GENERAL CONFLAGRATIONS

The accompanying photograph, taken by an inspector of the Underwriters Bureau of New England, shows the beginning of the conflagration of June 25, 1914, at Salem, Mass. It started during the daytime, was promptly discovered and a prompt response was made by the public fire department, but a combination of circumstances, such as poor building construction, and inadequate public water supply, etc., resulted in the destruction of property worth about $13,000,000.
under examination and the “exposure” adjoin by a “party wall” this fact should be brought out clearly and all communications described. The kind of business carried on in the exposing building, and the general character of the construction and protection should be noted.

The late Edward Atkinson said: “The only persons who can prevent loss by fire are the owners or occupants of the insured premises. Upon them rests the responsibility for heavy loss, if any occurs, in nearly every fire. All that the insurance company can do is to pay indemnity for loss, which, if large, in nine cases out of ten is due to the lack of apparatus for preventing loss, or to lack of care and order in the conduct of the work.” This applies to all manufacturing establishments, and though the risk being examined may be well managed and well equipped against heavy loss by fire, yet bad management and lack of appliances for fighting fire in the “exposure” may entail a sizable loss upon the former in spite of all safeguards possessed by it.

**Common Fire Hazards.**—These result from the kind of power, fuel, heat and artificial light used; storage and handling of lubricating oils; simple drying; ordinary use of inflammable volatiles, etc.

**Power.**—This may be water, steam, electricity, hot air, gas or vapor. If water power is used, the wheel or turbine should be firmly set. A $26,000 fire occurred in a paper mill at Conowingo, Md., from sparks caused by
GENERAL CONFLAGRATIONS
Paterson, N. J., February, 1902.
the giving way of the foundation of the water wheel. Several years previous to the case just cited, a fire that resulted in a considerable loss by fire started in a wheel pit of a similar mill in New England. (In neither case had sprinkler protection been provided over the wheel pits.) If steam power is used, the boilers should be so located and set as not to endanger any woodwork in their vicinity by radiation of heat, nor by a "back draught." The flues or "uptakes" through which the hot gases of combustion pass to the chimney or the stack should be clear from all woodwork and have ample air space to same. Iron stacks should have an air space all around them where passing through roofs and be provided with an iron collar with iron sleeve extending below the lower edges of nearby roof joists. Brick chimneys should be large enough and heavy enough for all the boilers, furnaces, etc., vented through them, should preferably be double walled, and no floor beams or roof joists should enter same for any distance. If electricity is used for power, it may be from a public source or it may be generated on the premises; the standards of the National Board of Fire Underwriters should be adhered to in either case.

Hot air, gas and vapor engines are used mostly where comparatively small power is required; they take up less floor space and a boiler room is done away with; special rules are laid down for their installation. The principal points to be examined are the nature of the agent used
and method of regulating the supply, manner of inducing combustion, arrangement of exhaust pipes, etc. Exhaust pipes should extend outside of buildings and be kept at a safe distance from any woodwork or combustible material. These pipes are liable to become very hot. Gas bag or pressure regulators should be enclosed in substantial gas-tight metal drums, vented to the outer air through a pipe used for no other purpose.

When chimneys or stacks pass through buildings there should be an air space all around them at floor passages, and all nearby woodwork should be protected with metal. In some instances, as in the case of a two story boiler house, the incidental heat is utilized for drying purposes. The surroundings in each case should suggest the necessary safeguards. The tops of boilers, furnaces, etc., are not safe places to dry anything of a combustible nature; nor should boardwalks be laid over the same.

Steam boilers are commonly insured separately by companies who inspect them periodically.

**Fuel.**—This may be coal, wood refuse, natural gas, or oil. In large plants where coal is used it is fed to the boiler fires by mechanical stokers as a rule, and brick water pits are built in front of the furnace doors to catch the ashes. In any event the ashes should be removed in metal receptacles to a safe distance from any frame wall, outside of all buildings. Where wood refuse is used for fuel it may be blown direct to the boiler fires or fed by
hand from a bin to which it has been blown. When the refuse is blown direct there should be a damper in the flue to prevent a “back draught” blowing fire back into the work rooms. Wood refuse too large to be picked up by a blower system is usually removed by hand. The flues (metal) should be kept tight, and the refuse bin should be substantially built of brick, with a standard fire door at the opening and so located as not to be exposed by the boiler fires. Depositing wood refuse on the boiler room floor, in the absence of a proper bin, is hazardous. A trail of shavings, etc., will carry fire. When natural gas is used there should be a regulator on the supply and a mercury gauge; the pounds pressure (or less) at which the gas is burned should be ascertained. The supply of natural gas is giving out in some localities and it may not be important in all cases to give the pressure. When “producer gas” (made on the premises) is used, the location of flues should be noted and if overhead should not expose any woodwork; the times and manner of “burning out” the soot should also be given. The charging floor of the gas producers should be entirely of iron and the building should not, preferably, expose others, especially when frame. When oil (petroleum, or petroleum products) is used for fuel a small standpipe system should be employed, and not a gravity system from the main supply. All the pipes should drain away from the burners, the main supply should be stored in a tank completely under-
ground at a safe distance from the works, and the oil should be pumped to the standpipe. The oil is sprayed at the burners by an air blast or by a steam jet. Floors under engines should be kept free from oil. Fuel oil systems require special consideration.

**Heating, Drying and Ventilating.**—Heating and drying may be by live steam or exhaust steam, hot air, or by stoves; or heating may be incidental, and drying may be done atmospherically. When steam is used the pipes are safest when overhead, but in all cases they should be supported on metal and be provided with metal collars (and air space) where passing through all woodwork; no combustible material should be stuffed behind steam coils, etc., nor any allowed to come in contact with the pipes, and the latter should be kept free from accumulations of lint, etc. When hot air is used the steam coils should be enclosed with metal and be accessible underneath for cleaning; the flues should be of metal and the supply of air taken from the outside. When stoves are used for either heating or drying they should be set over metal floor protection and the vent should have a metal collar where entering the chimney and also where passing through floors or partitions. Metal receptacles should be provided for ashes. The stovepipe, fire box and chimney should be examined for breaks.

**Lighting.**—This may be by glass or metal oil lamps, coal gas, gasolene, acetylene or electricity. The use of
glass lamps without metal cups to hold the oil bowl should be discouraged, if not prohibited. Lamps should be filled in one place and by one person—not where they are used. If gas is used the brackets should not be movable, especially where they can swing under shelves, etc.; and cages provided where there is any amount of inflammable refuse in the air. No open lights should be permitted in a room where an explosive dust or inflammable vapor is likely to be present.

All artificial lighting should be installed under the standards of the National Board of Fire Underwriters.

The use of vapor torches is objectionable.

**Oils, Etc.**—The kinds and amounts of oils, varnishes, etc., found, place where stored in bulk and quantity taken into the work rooms should be stated. Where any considerable supply is carried a separate fireproof building should be provided. This applies especially to the petroleum and coal oil products such as benzine, naphtha, benzole, naphthaline, etc.; and anything in which any of these inflammable oils is used as a solvent, as rubber cement used in shoe factories, hat factories, rubber works, etc. Pumping systems are used in certain kinds of risks, as textile mills, railroad shops, garages, varnish factories, rubber factories, etc. Benzine and similar cleaning fluids should be used only from safety cans. No oil giving off an inflammable vapor should be used near an open light, whether used clear or as a solvent or thinner; what is left
over at night of these oils should not be allowed to remain in the buildings. Large quantities of benzine and naphtha are used in oil cloth and linoleum factories, patent leather tanneries, rubber works, etc., and require special attention.

**Administration.**—Administration means management, order, cleanliness; disposition of refuse, oily waste and ashes; prohibition or restriction of smoking, use and carrying of matches, and spittoons; care of shafting, and cleanliness under and about bearings; general knowledge of the condition of the fire appliances and knowledge of the kind of service given by the watchman.

Order, management and cleanliness taken together may be the measure of the fire hazard. Some mills require more frequent cleanings because the refuse is made faster. A factory may seem dirty to the inexperienced eye and yet be "clean for the business." The report should state how often the refuse, as well as the cotton waste (or whatever else) oily from wiping machinery and oily rubbing rags, are removed and how they are disposed of. The inflammable refuse should be kept in metal barrels and oily rags in standard safety cans. Smoking should be prohibited and no wooden sawdust-filled spittoons allowed around; some establishments allow smoking at noon hour in stipulated places but this has its evils. Shafting should be kept sufficiently lubricated to prevent heating, and in alignment; fires are caused by over-heated bearings.
A mill that shuts down on Saturday should not be in dirty condition on Monday morning. The refuse of some mills is worked over into by-products on the premises; in others it is accumulated and sold for that purpose. The average establishment works about ten hours per day; breweries work longer hours; paper mills are in operation from Monday morning until Saturday night; electric light and power stations, and newspaper offices issuing a morning edition, work day and night; iron furnaces and glass furnaces remain in blast for months at a time; and so on.

**Private Fire Protection.**—A mill or factory may be provided with water casks and pails, sand pails, liquid chemical extinguishers, inside standpipes with hose connections and hose each floor, outside hydrants or connections on the outside of buildings with hose, a watchman (perhaps several in very large plants), a private fire brigade, and ladders and platforms, etc.

Casks and pails are probably the simplest and one of the most efficient means for putting fire out when it starts. Anybody can use them and the cost of maintaining them amounts to almost nothing. They should be provided in sufficient numbers, kept full of water and in readily accessible places, and reserved solely for fire purposes. Pails of sand are preferable to pails of water where there is likely to be fire in oils, paints, varnishes, etc. Fire bucket tanks, filled with a chemical solution and containing six
iron buckets immersed in the solution, may be preferred in places where the ordinary water casks and pails would be unsightly. These bucket tanks and also individual chemical pails have this advantage over water casks and pails that they are not apt to be used for service purposes. Liquid chemical extinguishers (portable or mounted on a carriage) generating carbonic acid gas are also valuable but should be tested at regular intervals to see if they are still active.

Standpipes inside buildings with connections and medium size hose each floor are also useful when properly supplied with water. City water or a private reservoir is the most effective supply if the pressure is sufficient. A tank supply on the roof is seldom satisfactory, and a small pump (not infrequently the only supply) cuts little figure. Pressure tanks have been used to a limited extent for supplying interior standpipes with water. There should be hose for each connection, reeled, kept attached and free from water (due to leaky valves, etc.), and provided with nozzles. Some buildings in cities have dry vertical pipes on the outside with connections at each story and on the roof for the use of fire engines.

Outside private hydrants are a necessity when public hydrants are lacking, and the connections on private hydrants should fit the public hose. If no public water system is available as a water supply for private hydrants there should be a reservoir of proper capacity and at suffi-
Section view of a 4-story building of "mill" operations of the Associated Factory Mutual Fire Insurance building construction, from a fire insurance view.

Stairs and elevators enclosed in fire-resistive to doors arranged to close automatically, (3) heavy floors arranged for both flooding and draining the freedom of all parts of building from concealed beams are usually self-releasing, which permits of damaging the walls. When buildings of this type sprinklers, large floor areas may be employed.
burning" construction, according to the specifications. The chief features of this type of construction are: (1) freedom of floors from all openings, (2) with all openings to each floor protected by fire floors and floor supports which burn slowly, (4) outside to prevent unnecessary water damage, (5) in walls, floors, partitions and roof. The floors of any floor burning away, or falling, without construction are completely protected by automatic fear of heavy fire losses.
Section view of a 4-story building of "mill" or "slow-burning" construction, according to the specifications of the Associated Factory Mutual Fire Insurance Companies. The chief features of this type of building construction, from a fire insurance viewpoint, are (1) freedom of floors from all openings, (2) stairs and elevators enclosed in fire-resistant towers with all openings to each floor protected by fire doors arranged to close automatically, (3) heavy wooden floors and floor supports which burn slowly, (4) floors arranged for both flooding and draining to the outside to prevent unnecessary water damage, (5) freedom of all parts of building from concealed spaces in walls, floors, partitions and roof. The floor beams are usually self-releasing, which permits of the beams of any floor burning away, or falling, without damaging the walls. When buildings of this type of construction are completely protected by automatic sprinklers, large floor areas may be employed without fear of heavy fire losses.
cient elevation to give a good pressure at the hydrants. Where a private reservoir is out of the question, a fire pump drawing from a well, or a brook, etc., may be acceptable as a water supply for hydrants, etc.

A watchman may be employed nights, Sundays and holidays—there should be one at these times especially in mills protected by automatic sprinklers. In large plants, like iron works, etc., there may be a force of uniformed private police who patrol the premises night and day. Certain plants running night and day, such as electric light and power stations and newspaper offices working nights, may not have a watchman because there are always some employees on hand. Watchmen should be required to make complete rounds at regular intervals beginning immediately after closing time. One of the best checks on watchmen are clocks with stations so distributed about a plant that the watchmen will be bound to see every part on each round. Records should be dated and say a month’s record kept on hand for inspection. Sunday and holiday watchmen should record at least three day rounds on the clock. Night watchmen may carry lanterns to see their way around, or in mills where electric lights are available the latter may be used in place of the portable light. In no case should the ordinary spring-bottom lantern be tolerated. Watchmen should not be permitted to smoke when on duty.

If a watchman is not provided with a time-detector,
he may be required to make his records on boxes connected with a central station (A.D.T.). "Runners" are constantly on duty at central stations to ascertain the reason for the failure of watchmen to report at the proper time. Central-station boxes are also used for giving alarms of fire, the central station in turn transmitting the alarm to the fire department.

Thermostats connected to the nearest fire house give alarms of fire automatically, and a direct connection with the public fire alarm system may be secured by the use of auxiliary boxes distributed throughout a building. Auxiliary boxes save the time consumed in running to street boxes and give an alarm the same as if rung in from the latter.

An inspector should understand the principles on which pumps (especially the underwriter pattern) are built, how to figure their capacity, what horse power of boilers is required to run a given size pump, and how to test pumps; the laws of water in motion and in a state of rest; the use of gate valves and check valves to control the flow of water in pipes; and the fact that water pressure is due to height of elevation of the supply irrespective of the volume of the supply. Also that when two supplies of different pressures are joined together, the available pressure is the greater of the two.

Duplex-piston, rotary and centrifugal pumps for fire service, to be driven by steam, water or electric power, have
been standardized by the National Board of Fire Underwriters. Fire pumps are built to deliver 500, 750, 1,000 and 1,500 gallons per minute. A pump delivering less than 500 gallons of water per minute can not be considered a fire pump.

Centrifugal pumps are those in which the water is given a high velocity by revolving impellers. The velocity of the water on leaving the impeller is reduced by suitably arranged passages and appears as pressure. Higher pressures may be secured by increasing the speed, or by arranging two or more impellers in series. To avoid excessively high speeds the latter method is usually employed, forming the multi-stage pump.

The turbine form of centrifugal pump is one employing diffusion vanes for directing the flow of the water leaving the impeller, and will probably make possible higher efficiencies. Either type, however, meeting the specifications of the National Board of Fire Underwriters may be acceptable.

No underground pipe for hydrants for fire service should be laid of less than 6 inches diameter.

Cast iron pipe is cheaper than hose. With 600 gallons of water per minute flowing in 6-inch pipe having an ordinary amount of rust in it, a pressure of 75 pounds can be maintained at the hydrant, with a pressure not over 110 pounds at the pumps 1,000 feet distant, and this would give two streams through 50-foot lines of hose and
1½-inch nozzles, with 60 pounds' pressure at nozzles. This same pressure of 110 pounds would deliver through 1,000 feet of best cotton rubber-lined hose and a 1½-inch nozzle only 190 gallons of water, while the pressure at nozzles would only be 25 pounds, which pressure can hardly be considered fair for a fire stream. A pressure of 256 pounds per square inch at pump would be required to deliver 600 gallons of water through two 1,000-foot lines of cotton rubber-lined hose with 1½-inch nozzles.

**Public Fire Protection.**—The larger cities have paid fire departments with modern apparatus, fire patrols, a public fire alarm system, and plenty of hydrants supplied with water through various sizes of pipes from reservoirs and standpipes, or from a direct pumping system.

Fireboats are necessary for the protection of property situated along the water front of a city.

Separate high-pressure pumping systems for fire purposes are in operation in certain districts of New York City, Philadelphia, Brooklyn, Baltimore, Cleveland, San Francisco, Cal.; Oakland, Cal.; Lynchburg, Va.; Jacksonville, Fla.; and at Coney Island, N. Y. Gas power is used at Philadelphia and Coney Island. Electricity from a private corporation is used for power in New York City and Brooklyn.

Special fire main systems supplied by fire boats only are installed in a number of cities.

During the great earthquake-conflagration of April 18,
1906, in San Francisco, the water supply was destroyed by earthquake shocks.

The important points about water supply are the amount of water available, character of supply (gravity or pumping), distribution, number of hydrants, the pressure at the hydrants, and the sizes of the street mains. Pumping units and delivery mains should be in duplicate. There should be no "dead ends" where mud and sediment may collect.

When a main line railroad passes between the public hydrants and a plant, provision should be made for passing the hose under the tracks, as otherwise a train may render hose connected to hydrants so situated useless.

In the smaller cities and towns there may be available only a volunteer fire department, few or no hydrants at all besides those belonging to the mills, a low pressure water system or none at all, and no alarm system. Where there is only a volunteer department a private fire brigade in each mill is invaluable and several neighboring mills having their own brigades and good systems of hydrants can render much assistance to one another in times of fire.

Conflagrations have made it necessary many times in recent years for cities to ask for outside assistance. Little assistance can be given unless the hose couplings of the assisting fire departments will fit the hydrants of the city where the conflagration is raging. Where "chuck" hydrants are used (especially in New England cities and
towns), a good supply of "chucks" (portable hydrant heads) should be kept on hand. The National Board of Fire Underwriters, through the efforts of Mr. F. M. Griswold and others, standardized hose and hydrant couplings for the use of public fire departments, and secured the cooperation of the Government toward the adoption of a universal hose coupling.

The value of cooperation between cities in fighting conflagrations also depends on how much apparatus and how many firemen can be spared, and how quickly they can reach the place where they are needed. When transportation by railroad is available, it is necessary to have a standing arrangement with the road. Specially designed trolley cars have been adopted by some cities.

Another equally important factor is getting the apparatus and the firemen back home if they should be needed there. The firemen away from home should keep in constant communication with their own headquarters.

Some cities can get no assistance in fighting a general conflagration, because there is none to be had.
AUTOMATIC SPRINKLER PROTECTION

AUTOMATIC extinguishment of fires burning inside of buildings by means of devices called automatic sprinklers is about forty years old. The first practical automatic sprinkler was perfected in 1875 by Henry S. Parmelee, of New Haven, Conn., and that year about 2,500 "Parmelee" automatic sprinklers were installed in the Troy Mills, Richard Borden Mills and Mechanics Mills, Fall River, Mass. They were manufactured by Frederick Grinnell, of Providence, R. I.

Several hundred different automatic sprinklers have been invented since, but a very small number proved to have real merit and all of the early types have been replaced by more modern devices.

At present thirteen makes of automatic sprinklers are approved by fire underwriters. Their names and the names and addresses of the manufacturers are given under "Approved Automatic Sprinklers."

The underlying principle of automatic extinguishment of fires will be readily understood from the following remarks of the late Edward Atkinson, LL.D., Ph.D., of Boston, Mass., president of the Boston Manufacturers Mutual Fire Insurance Company, about a fire in the base-
ment of a building occupied for the storage of woolen goods in the piece: "A fire occurred at the bottom and back part of a considerable stock of heavy woolen goods, which had been piled against the wooden furring to the party wall. In the party wall was a recess, in which the lead water pipe had been laid, bringing the supply of water. The heat of the fire burned through the woodwork, melted the lead pipe and let on an abundant supply of water, nearly sufficing for its extinction."

Automatic sprinklers extinguish fires where they occur in the same way as the lead water pipe did. They are held shut by a fusible alloy, with a known melting point, until the flame or the heat of a fire under or near them causes the alloy to melt and release the water in the piping to which the automatic sprinklers are attached.

An automatic sprinkler equipment consists of:
1. Small piping suspended from the ceiling.
2. Automatic sprinklers attached to the small piping.
3. Large pipes running vertically and connected with the small piping on every floor.
4. One or more supplies of water, such as a tank above the roof, a pump in the basement or in a separate house, and a connection from a public street main.
5. Gate and check valves to control the flow of water.
6. Alarm valves to give notice of the opening of one or more of the automatic sprinklers.
7. Water gauges to indicate the water pressure in the piping.

8. Dry-pipe valves to hold back the water to the automatic sprinklers in a room, or a building, that is not heated, until one or more of the sprinklers opens, in order to prevent freezing of the water in the small piping. Until an automatic sprinkler on a "dry-pipe system" opens the piping contains nothing but air under suitable pressure.

9. Outside connections near the sidewalk, for the use of public fire engines, to give the automatic sprinklers in a building an additional supply of water.

10. Supervisory service from a central station to insure prompt notice of the opening of sprinklers, or the closing of gate valves, etc., for any reason.

Other details will be found in the rules and requirements recommended by the National Board of Fire Underwriters.

**Approved Sprinklers.**—The names and addresses of manufacturers of approved automatic sprinklers, dry-pipe valves, etc., together with the trade names of the latter, will be found in the advisory lists published by Underwriters' Laboratories, Inc., Chicago, Ill., and by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, Boston, Mass. These lists are revised as found necessary and the latest lists should be consulted. The automatic sprinklers of the following
APPROVED AUTOMATIC SPRINKLERS

THE "ESTY", TYPE B

The H. G. Vogel Company, Sole Agent,
New York City.

Check Valves.—Check valves, like gate valves, are used to control the flowing of water in piping, but they are essentially different from gate valves. Check valves have no handle and open in only one direction, under the pres-
APPROVED AUTOMATIC SPRINKLERS

THE "GRINNELL", IMPROVED 1903

General Fire Extinguisher Company,
Providence, R. I.
sure of the flowing water. When the water starts to flow in the opposite direction, the check valve closes and if tight stops the flow of water in that direction, whence the name "check valve". Check valves have two important uses in automatic sprinkler equipments when there are two or more water supplies connected with the equipment at different points. A check valve (and a gate valve) would be placed in the piping at the entrance of each water supply, between the gate valve and the water supply. This prevents either of the water supplies from running to waste, and also permits the equipment to receive the benefit of the higher of the two pressures furnished by the water supplies. If an equipment is connected with a water tank at the top, and with a public street main at the bottom, a check valve in the latter connection prevents the water from the tank running into the public street main, and if the pressure furnished by the public water system is higher than the pressure from the tank supply, the public water pressure will close the check valve in the connection from the tank supply, thereby giving the sprinkler equipment the benefit of the full pressure from the public water supply. If there were no check valve in the connection from the tank supply, the pressure from the public supply would cause the tank to overflow. When there is a third water supply from a pump, for an automatic sprinkler equipment, the pump usually gives the highest pressure and instantly closes the
APPROVED AUTOMATIC SPRINKLERS

THE "GRINNELL", IMPROVED 1903

(Open)
check valves in the connections from the other water supplies. There should always be a check valve in both inlets of a Siamese connection for the use of fire engines.

**Dry Systems.**—In a "dry-pipe system" the piping contains only air under pressure, until one or more of the automatic sprinklers operates to extinguish a fire, and special types of valves called "dry-pipe valves" are used to hold back the water supply. These "dry-pipe valves" are kept closed by the air pressure in the piping and after the flame or heat of a fire has caused one or more of the automatic sprinklers to open, the air in the piping must escape before the "dry-pipe valve" can open to allow the water supply to flow into the piping to feed the automatic sprinklers that have been opened by a fire. Because of this perceptible delay in the water reaching a fire in a building with a "dry-pipe system" of automatic sprinklers, the number of automatic sprinklers which can be controlled by one "dry-pipe valve" is limited, and the number of "dry-pipe valves" may be increased to avoid a serious delay in the water supply reaching automatic sprinklers that have opened.

After a "dry-pipe system" has operated, all the piping must be carefully drained, new sprinklers substituted for the ones that opened, and the air pressure pumped up again in the piping. To accomplish this it is necessary to understand how to "set up" the "dry-pipe valve" be-
APPROVED AUTOMATIC SPRINKLERS

THE "GLOBE", ISSUE B

Globe Automatic Sprinkler Company, Cincinnati, Ohio.
fore starting to pump up the air pressure that keeps the “dry-pipe valve” closed.

“Dry-pipe systems” are usually found in warehouses, wharf buildings and other structures that are not heated. An interesting “exception” is the automatic sprinkler equipment in the car storage section of the Broadway branch of the New York City subways beginning at 135th street. Both ends of this section of subway are open, but the temperature never falls to the freezing point of water and the sprinkler equipment is maintained as a “wet system” all the year.

Sometimes an automatic sprinkler equipment may be maintained on a “wet system” during the summer and fall seasons, and on a “dry-pipe system” during the winter months. The usual “dry-pipe valves” are used and these are kept open when the automatic sprinkler equipment is on a “wet system”. This combination of “systems” is objectionable, chiefly because it permits sediment to collect in the piping.

“Failures” of Automatic Sprinklers.—Automatic sprinklers are said to have “failed” in some cases to extinguish fires, but this is not true. Some of the more common causes of alleged “failures” are: Gate valve closed, shutting off the supply of water. Broken pipes, allowing water to be wasted. Water turned off too soon. Unprotected floor openings (stairways, elevator shafts, chutes, belt ways, etc.), allowing an unnecessary large
APPROVED AUTOMATIC SPRINKLERS

THE "INTERNATIONAL", ISSUE B

International Sprinkler Company,
New York City.
number of automatic sprinklers to open and exhaust the water supply. Hydrants, supplied from same connection as the automatic sprinklers that was only large enough to supply one or the other, used and water drawn away from the automatic sprinklers. Fire started in unprotected building and communicated through unprotected windows to building protected by automatic sprinklers, causing a large number to operate at one time and exhaust the water supply. High wind blowing through open windows and carrying heat from a fire away from the nearest automatic sprinklers.

**Freezing of Water.**—When buildings protected by automatic sprinkler equipments are not heated there is danger of the water in the piping freezing in winter. When water in piping does freeze, the piping is liable to burst from the expansion of the ice, as it begins to thaw. There is a similar danger in the piping of dry-pipe automatic sprinkler equipments from freezing of condensed moisture. The ice clogs the piping and its presence may not be discovered until a fire has occurred and the sprinkler equipment has failed to extinguish it.

**Gate Valves.**—Gate valves are used to control the flowing of water in piping. When closed, they prevent the flowing of water in either direction. When open, the water may flow in both directions. Gate valves are placed in the piping at the entrance of all water supplies to an automatic sprinkler equipment, and on each floor of a
APPROVED AUTOMATIC SPRINKLERS

THE "MANUFACTURERS", ISSUE C

Automatic Sprinkler Company of America,
New York City.
building, to control the flow of water to the automatic sprinklers. When a plant equipped with automatic sprinklers consists of several buildings, the water for the automatic sprinklers in each building is usually controlled by a gate valve placed in the branch pipe (underground) leading into the building and at a point about forty feet away from the building, to allow the water for the automatic sprinklers in the building to be shut off without entering it. This is accomplished by means of an indicator post extending from the gate valve to a point about three feet above the surface of the ground.

After a fire has been extinguished by automatic sprinklers, the water must be shut off at the nearest gate valve to the sprinklers that operated before new sprinklers can be substituted for them, to put the sprinkler equipment into commission again. This is frequently done in large cities by the Fire Patrol, or it may be done by the engineer of the building.

Leaving gate valves closed when they should be open is fatal to automatic sprinkler protection, because automatic sprinklers must be properly supplied with water to do their work. When gate valves must be closed for any reason for any length of time, such as one hour or longer, the safest plan is to station a man at every closed gate valve and give him positive instructions to instantly open the gate valve in his charge if a fire starts.

Supervisory service from a central station insures
THE "NERACHER", IMPROVED 1902

General Fire Extinguisher Company,
Providence, R. I.
prompt notice of the partial closing, full closing, partial opening and full opening of each gate valve, for any reason.

An elaborate tagging system has been developed for keeping the engineer of a plant, or whoever has charge of the private fire protection, informed of the closing of gate valves. When a gate valve is closed, a tag is fastened to it and another tag is hung on a board in the engine room, or some other conspicuous place, to show exactly which gate valve is closed. All gate valves are numbered for quick identification and on this board is a hook for every gate valve, with the number underneath. The tell-tale tag stays on the proper hook until the closed gate valve has been opened.

**Hose Connections.**—Small hose is sometimes permitted to be connected to automatic sprinkler piping and is handy for both wetting down material inside of buildings after a fire has been extinguished by automatic sprinklers and for throwing water on fires which cannot be reached by the nearest automatic sprinklers because of obstructions to the distribution of water from the automatic sprinklers.

**Loss of Pressure.**—There is a constant loss of pressure in water pipes due to friction between the water and the inside surface of the pipes. This is also true of hose. Bends in pipes, fittings, valves, etc., all tend to reduce the pressure under which water is flowing through them.
APPROVED AUTOMATIC SPRINKLERS

THE "NIAGARA", ISSUE B

Automatic Sprinkler Company of America, New York City.
These losses of pressure can be considerably reduced by the use of smooth piping, long bend fittings, minimum number of valves, etc.

**One-Supply Equipments.**—Automatic sprinkler equipments with one water supply are better than none, provided the one water supply is ample and reliable, but they cannot be considered standard (see Water Supplies, Number of). The exceptions to this rule are automatic sprinkler equipments having a steel pressure tank as a water supply and a connection with a central station for full supervisory service (A. D. T. supervisory service). When an old building is not strong enough to support a gravity roof tank, and a tank cannot be placed on a trestle built up from the ground, a good water supply may be obtained from a public street main if of proper size and fed both ways, and the pressure in the street main meets the requirements.

**Partial Equipments.**—Automatic sprinkler equipments which do not protect every room, every basement, every blind attic, every stationary closet, etc., of a building, or plant, may not do the work expected of them if fires start in places where there are no automatic sprinklers and gain much headway. Automatic sprinklers are intended chiefly for extinguishing incipient fires and not conflagrations. When a new building is added to another, or to a group, that is protected by automatic sprinklers, the new building should also be protected with automatic
APPROVED AUTOMATIC SPRINKLERS

THE "ROCKWOOD", ISSUE D

Rockwood Sprinkler Company,
sprinklers unless there is some good reason for not so doing.

**Pipe Sizes.**—An examination of an automatic sprinkler system will show that the piping is not all the same size in diameter; that the vertical pipes (“risers”) are the largest and that the branch lines (“laterals”) suspended under the ceilings are not the same size for their entire length. There are two reasons for this: (1) Every pipe has a definite carrying capacity. (2) A pipe must be large enough to supply water, under proper pressure (pounds to the square inch), to all of the automatic sprinklers attached to it, or at least the number that is liable to be opened by the heat or flame of a single fire. Pipe sizes for automatic sprinkler equipments will be found in the standard recommended by the National Board of Fire Underwriters. It will be noticed that a given number of automatic sprinklers (or heads) is allowed on a pipe of a certain diameter. Each size pipe is large enough to feed the number of automatic sprinklers allowed on it, including loss of pressure due to the water rubbing against the inside surface (friction). The smallest piping is at the ends of lines (“laterals”); the largest pipes are the main supply pipes. Doubling the diameter of a pipe increases its carrying capacity four times, approximately. Suppose a 2-inch water pipe is used for a certain purpose. The cross section of a 2-inch pipe contains 4 square inches, which is found by simply squaring
SAVED BY SPRINKLERS

Automatic sprinklers saved these buildings from the attack of an "exposure" fire across the street. Wooden window frames and sash in the lower building were destroyed.
the diameter (multiplying the diameter by itself). A pipe of twice the diameter, that is 4 inches, will have a cross section of 16 square inches which is four times the number of square inches in the cross section of a 2-inch pipe. The opening (orifice) of an automatic sprinkler is \(\frac{5}{8}\)-inch in diameter, or .39 square inches. Only one automatic sprinkler is allowed by modern pipe schedules to be supplied by a pipe 1-inch in diameter which is twice the diameter of the orifice of an automatic sprinkler, or .7854 square inches.

**Private Fire Brigades.**—Private fire brigades organized among the workmen of a manufacturing plant, department store, shipping terminal, etc., drilled in the use of private fire appliances, such as hose streams from interior standpipes, yard hydrants, etc., are invaluable for helping automatic sprinklers do their work, by backing them up with hose streams judiciously used. These brigades are usually always available and can be called into action by the sounding of an alarm on an interior electric system, by the blowing of a whistle, etc.

**Pumps.**—Four kinds of pumps are used for furnishing a supply of water under pressure to automatic sprinkler equipments: (1) Duplex piston pump, driven by steam; (2) rotary pump, driven by water wheels; (3) triplex power pump, driven by gas engines or by electric motors; (4) centrifugal pumps, driven by electric motors. The first three types have been in use for a long time, the
SAVED BY AUTOMATIC SPRINKLERS

Interior view of the higher of the two buildings shown on Page 77, after the fire. The heat from the fire across the street opened a large number of automatic sprinklers in this building.
fourth (centrifugal type) is still being developed, but its possibilities as a reliable water supply for fighting fires are recognized by fire protection engineers, especially its large capacity. A pump to be acceptable as a water supply for automatic sprinkler equipments (and for private yard hydrant systems) must be of special design and have a capacity of not less than 500 gallons per minute. The regular sizes are, (1) 500 gallons per minute pumping capacity; (2) 750 gallons per minute pumping capacity; (3) 1,000 gallons per minute pumping capacity; and (4) 1,500 gallons per minute pumping capacity. Steam, rotary and centrifugal pumps have been standardized and copies of specifications may be obtained from the National Board of Fire Underwriters, New York. Besides being of proper design and capacity, the value of a pump for fire-fighting purposes depends on (1) whether it is located in a suitable place, particularly where it can be reached in safety during a fire; (2) whether there is some one on hand when a fire starts who knows how to operate the pump; (3) whether there is a sufficient supply of water available (enough to last for an hour or more); (4) whether there is ample power for driving the pump continuously for an hour or more; (5) whether the pump can be disabled by the breaking of a steam pipe supported overhead, by the breaking of an electric cable supported overhead, etc. Some attempt has been made to equip steam pumps with automatic regulators to cause them to
A "SPRINKLERED" RISK BEFORE A FIRE

(See Page 83.)
start up automatically on the operating of one or more automatic sprinklers, as a means of promptly furnishing them with a supply of water under a good pressure, but this necessitated keeping a pump constantly in operation, which proved to be wearing on the moving parts, such as the pistons of a duplex piston pump. Another method employed was to attach a small auxiliary pump to a large one, the small pump being kept in operation until one or more automatic sprinklers operated, when the large pump would start up automatically. Basements are poor places for fire pumps unless the building is of fireproof construction, a special room is partitioned off for the fire pump and the room can be entered directly from the outside. Fire pumps usually have one hose connection for every 250 gallons per minute capacity. The most dependable supply of water for a fire pump is a private reservoir of proper capacity. When a pump takes suction from a stream or river, the end of the suction should be sunk in a special crib, etc., to prevent clogging of the strainer on the end of the suction pipe. Direct suction from a city water pipe may not be reliable when there is a very heavy draught on the same pipe by fire engines, etc. Reservoirs may be placed in the basements of fireproof buildings, or outside. Long suctions and deep lifts are objectionable because of the power that must be exerted by a pump to deliver water.

Steamer Connections.—Siamese connections on the
A "SPRINKLERED" (?) RISK AFTER A FIRE

The water supply here was unreliable.
outside of buildings, near the sidewalk, are commonly provided for automatic sprinkler equipments with the idea that they will be used by public fire departments to give the sprinklers an additional supply of water by connecting fire engines with them, but these siamese connections are seldom used. Siamese connections should always be provided with check valves (in each branch), but never with gate valves.

**Tanks.**—Two kinds of tanks are used for storing water for supplying automatic sprinkler equipments, (1) gravity tanks and (2) pressure tanks. Large gravity tanks, having a capacity of 100,000 gallons of water, are frequently used both for supplying the automatic sprinkler equipment in a mill and the private yard hydrant system belonging to same. Gravity tanks are built of wood, or steel, or of reinforced concrete. They are commonly supported on trestles on the roofs of buildings, and they are also supported on trestles built up from the ground. The capacities of gravity tanks vary from 5,000 gallons to 100,000 gallons, according to the number of automatic sprinklers that are expected to operate in the largest room area, and according to whether hose lines or yard hydrants are also to be supplied by a gravity tank. Great care must be taken in designing the supports for gravity tanks on account of the weight of water. A gallon of water weighs 8 1/3 pounds, a cubic foot of water weighs 62 1/2 pounds. Not including the tank itself, a 5,000-gallon
COLLAPSE OF GRAVITY TANKS

Damage caused by the collapse of the supports of a gravity roof tank intended as a supply for an automatic sprinkler equipment.
tank would mean a dead weight of 41,650 pounds; a 10,000-gallon tank, 83,200 pounds; a 20,000-gallon tank, 166,400 pounds; a 30,000-gallon tank, 249,600 pounds. (Dividing these weights by 2,000 will convert them into tons.) A large number of gravity tanks supported on the roofs of buildings have collapsed, causing heavy property damage and in some cases loss of life. Probably the safest location for a gravity tank that must be placed on a building is directly over a brick stair tower. Old buildings may have to be strengthened to carry the extra load represented by a gravity tank. In designing reinforced concrete buildings which are to be equipped with automatic sprinklers, four or more of the columns may be made extra large to carry the weight of a gravity tank above the roof line. Wooden tanks are always liable to be destroyed by fire. In recent years gravity roof tanks have been enclosed. Wooden trestles for supporting gravity tanks are always objectionable. Steel trestles, when standing near buildings, are almost as objectionable as wooden trestles, unless they are completely encased in fireproofing, as concrete. A few trestles and tanks have been built wholly of reinforced concrete, in one structure.

Pressure tanks are always built of steel and resemble steam boilers in a general way. They are commonly used as a water supply for automatic sprinkler equipments in high buildings because it is almost impossible to obtain a connection from a public street main under sufficient
pressure to furnish a supply of water to the automatic sprinklers in the upper stories. Pressure tanks are usually placed on the roof and enclosed. They are filled two-thirds with water and one-third air under a pressure of seventy-five pounds to the square inch, this pressure being maintained constantly. As the water in a pressure tank is discharged into an automatic sprinkler equipment, the air pressure which forces the water out of the tank diminishes, the last water being discharged from the tank under about fifteen pounds pressure to the square inch. The total capacity (water and air) of pressure tanks varies from 4,500 gallons to 9,000 gallons, which is about the largest steel pressure tank that has ever been used for supplying automatic sprinkler equipments.

Batteries of pressure tanks, located on the roof and enclosed, constitute the sole automatic water supply for the automatic sprinkler equipments in some high buildings.

The advantage of pressure tanks is that the water discharged by the first automatic sprinkler caused to operate by a fire is under a pressure of more than seventy-five pounds to the square inch, and one automatic sprinkler is more liable to prove sufficient to extinguish a fire than when the water pressure is much lower. The pressure from a gravity roof tank on the automatic sprinklers in the top story of any building is low, due to the slight
“head” between the automatic sprinklers there and the bottom of the gravity roof tank (see Pressures).

The disadvantage of pressure tanks is their limited water capacity, but this can be overcome by adding pressure tanks, thereby increasing the total amount of water in storage for supplying an equipment of automatic sprinklers.

To ascertain the capacity in gallons of a circular tank, square the diameter in feet, multiply the result by the inside depth of the tank in feet, and then multiply again by the decimal 5.87. To find the capacity in gallons of a rectangular tank (one having three dimensions, length, breadth and depth), multiply the length in feet by the breadth in feet, multiply the result by the depth in feet, and multiply again by the decimal 7.48.

Wooden tanks should not be painted, after erection, under about two years, to give the wood a proper chance to season; otherwise dry rot may take place and the wood crumble to pieces.

**Water Pressure.**—The pressure from a tank of any size is caused by the natural force called gravity and varies according to the elevation of the tank above any given point, as any floor of a building. Water pressure furnished by reservoirs located on hills is caused by the same natural force. One foot of elevation exerts a pressure of .434 pounds to the square inch. Multiplying the height in feet of any tank or reservoir above any given point by the
decimal .434 will give (approximately) the pounds pressure per square inch at that point. When water pressure is furnished by a pump the pump must, in raising water to any given point, first overcome the effect of the natural force called gravity before it can exert any pressure at that given point. As a matter of fact, the pump must do more than that because of certain losses. What has been said about a pump is also true of a pressure tank when located at the lowest point in a building. When a pressure tank in which an air pressure of 75 pounds to the square inch is maintained is located at the top of a building, the water pressure at any given point below the pressure tank will be 75 pounds plus the pressure due to the elevation of the pressure tank above that point. Water pressure in an enclosure, such as a tank, is exerted equally in all directions. When the surface against which water under pressure is exerted contains less than a square inch, the pressure from the water on that surface will be reduced accordingly. This is especially true of the valve seats of automatic sprinklers, and of pipes whose diameter contains less than one square inch.

**Water Seeks Own Level.**—Water always seeks its own level. If two tanks at different elevations (however slight the difference) be connected together, the water in the higher tank will run into the lower tank until the level of water in each tank is the same, or the lower tank overflows. Where two tanks at different elevations are con-
nected with the same automatic sprinkler equipment this may be prevented by placing a check valve in the discharge pipe from the lower tank. When an automatic sprinkler equipment has more than one water supply, there should be a check valve near the entrance of each water supply, so the equipment will receive the benefit of the highest pressure furnished by any of the water supplies, and so no water will be lost. (See Check Valves.)

**Water Supplies, Number of.**—There should be at least two water supplies for every automatic sprinkler equipment, so that if one of them is not available for any reason when a fire occurs the sprinkler equipment will not be without water. Ordinary combinations of water supplies are a gravity tank and a connection with a public street main; a gravity tank and a fire pump; a gravity tank and one or more pressure tanks, etc. The advantage of a gravity tank is that just so much water is constantly available for the automatic sprinkler equipment, but the value of any gravity tank depends on its capacity and the elevation of the bottom about the highest line of automatic sprinklers. Water pressure furnished by a gravity tank is due solely to the elevation of the tank above any given point in a building and not to the quantity of water in the tank. The water pressure from a gravity tank is the least in the top story of a building and the greatest in the basement (or the lowest point.) (See Water Pressure). The quantity of water that can be furnished by
any tank is obviously limited to the capacity of the tank (unless some provision is made for automatically refilling the tank, which has rarely been attempted). A connection of proper size with a public street main may be preferable to a gravity tank because it gives an automatic sprinkler equipment an unlimited supply of water but the pressure in the public street main must be sufficient to maintain the proper pressure on the top line of automatic sprinklers. The size of a connection between an automatic sprinkler equipment and a public street main should never be less than the diameter of the main supply pipe (or riser) in the building. Connecting fire engines to hydrants on a public street main that is supplying water to the automatic sprinklers in a burning building may render the public street main worthless as a water supply for the automatic sprinklers in the burning building, by drawing the water away from them. Broken pipes will make public street mains of no value as water supplies for automatic sprinkler equipments. Pumps are of no value as water supplies for automatic sprinkler equipments unless they are accessible and there is somebody on hand who knows how to run them.

**Water Supplies, Size of.**—The size of any supply of water for an automatic sprinkler equipment is determined by the largest number of sprinklers liable to be opened by any single fire, and this depends on the area of the largest room. When floor openings are left un-
protected there is a grave likelihood of automatic sprinklers being opened where there is no fire, thereby causing unnecessary water damage and taking water away from the automatic sprinklers directly over a fire. The number of sprinklers opened by a single fire varies greatly. One rule is to provide enough water for one-half the total number of automatic sprinklers in the largest room for one hour. The combustible nature of the contents of a building will influence the number of automatic sprinklers opened by a single fire. Open windows when a high wind is blowing will result in a large number of automatic sprinklers opening. Large work tables, stock shelves, etc., will retard the opening of the nearest automatic sprinklers to a fire and thus permit the fire to spread and open a larger number of automatic sprinklers. Flash fires in oil, dust, cotton, etc., open large numbers of automatic sprinklers.

**Wet Systems.**—In a “wet system” the piping is constantly filled with water under pressure, which varies on the different floors of a building (see Pressures). A “wet system” can be used only in buildings where there is no danger from freezing. A “wet system” is preferred to a “dry pipe system” because it operates quicker and there is no loss of pressure in the piping.
AUTOMATIC Sprinkler Protection has done more to foster the industrial growth of the United States than any other factor, by making serious fires in all kinds of buildings preventable. The "ESTY" has had a big share in this important work for many years.

It has proved positive in action and efficient in results.

Drop us a line

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"The Pioneer in Automatic Fire-Fighting"

THE "ESTY" AUTOMATIC SPRINKLER

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