Fire Prevention*

The Control of Fires Through Scientific Methods

By Edward V. French†

In recent years much has been said and written in this country regarding the conservation of resources, and there is general unanimity of opinion that conservation is vital to the future welfare of the nation. In the United States, property to the value of 250 million dollars is, on the average, annually consumed by fires. This is absolute waste. Nothing is produced. If we cut our woodlands for lumber and paper we at least have something as a product, but the heap of ruins left by a conflagration is waste of the most extravagant and useless sort.

For many years the scientific method of fire prevention has been applied in a selected class of manufacturing properties. The result has been a reduction in fire loss to but a few cents per year for each $100 of value in these properties. The work thus carried on has broadened with the growth of the country until it now includes a large percentage of the best manufacturing plants. It is one of the oldest and most successful examples of the conservation of resources.

About seventy-five years ago Mr. Zachariah Allen, a cotton manufacturer of Rhode Island, conceived the idea of materially reducing fire costs and interested a number of other manufacturers in a plan for mutually sharing losses. Self-interest encouraged care and secured the intelligent co-operation of all who joined in the plan. Attention was early given to causes of fires and to means of preventing them, and this was the starting point of what now has become the important specialty of fire protection engineering.

In a memorial published at the time of his death it is stated that he was the original inventor of the automatic cut-off valve for steam engines, undertook and carried out the first systematic measurement of the Niagara River over its great falls, traveled in this country and abroad, and had a keen appreciation of the resources of America. He was one of those men who get out of the ordinary ruts and who really originate and carry out ideas. In this memorial appear letters from many prominent men, including President Rogers of the Institute.

The early textile mills in this country generally had heavy brick or stone walls and substantial plank floors. They were frequently of five or six stories in height, and had steep roofs, often covered with shingles. The usual power was water wheels. They were heated by wood stoves and lighted by whale-oil lamps. The cotton and greasy wool used created hazardous conditions. Fire protection was often provided by rather crude plunger pumps, driven from the water wheels, a standpipe was carried up through the mill with hose connections at the different floors, and casks and pails filled with water were placed at convenient points. The main dependence, however, was upon good care and the maintenance of such conditions that fires would not start.

Of course fires did occur, and many bad losses were met by these pioneer fire protection engineers, but from each severe experience some valuable lesson was learned, and the knowledge thus gained stored up for future application. It was early found that the old steep roofs, with their inaccessibility and large amounts of fuel, were especially hazardous features, and as they burned off solid flat roofs of plank were provided, while many mills were induced to remove the bad roofs without waiting for a fire.

The advantage of good construction was apparent from the beginning, and some mills in New England, though built over seventy-five years ago, still stand ways and elevators in brick towers. This type of ways and elevators in brick towers. This type of construction early became known as slow burning, from the fact that the solid masses of wood in the timbers and plank resisted fire for a long time before being sufficiently burned to be seriously weakened. Contrasted with this construction is the ordinary type using joists and thin floors, in which the surface exposed to the fire is much greater than when plank and timber are used, and in which the wood is in such small pieces that a little fire quickly destroys all strength, thus resulting in a quick-burning structure.

The need of having floors tight, so that no vertical openings would exist through which fire could quickly pass from story to story, was early recognized. It later became the practice to inclose the main driving belts in brick towers, and in practically all of the older mills where the belts were originally carried from water wheels or engines through the floors, making considerable openings, incombustible partitions have been built around the belts so as to eliminate this danger.

Special consideration was given to isolating hazardous processes, and one of the first steps was to put the picker room of cotton mills in an outside building, where the frequent fires which were inevitable could quickly be extinguished without endangering the main part of the plant. In a similar way all other processes containing peculiar hazards have been dealt with, each case being considered on its own merits, and the solution adopted best fitting the conditions.

One of the first improvements upon the primitive protection afforded by standpipe and fire pail came about 1850, in the development of perforated pipe sprinklers. These consisted of lines of pipe, one carried through each mill bay, drilled with small holes, designed to throw water against the ceiling. Branch pipes were connected to a feeder, and all supplied by a riser coming up through the building, usually a separate one for each floor. Connection was made in the yard to a main supplied with water from the fire pumps or other sources, and valves in the yard controlled different sections. When fire occurred the valve controlling the water for the perforated pipes in that section was opened, and the whole room deluged.

The idea of such protection came from England and its possibilities were at once appreciated. It was developed through scientific methods, and many experiments on test equipments, thus determining the proper size of pipes and the best size and arrangement of holes, so that a fairly uniform and very hard rain would be delivered over the whole of any protected room.

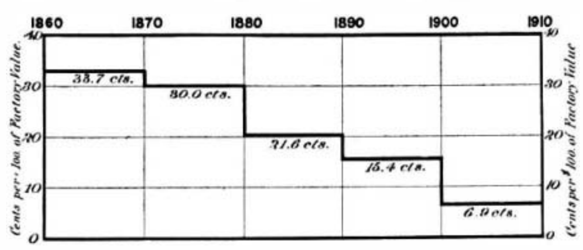

Fig. 1. Fires which have occurred in the Association of Factories showing the effect of the introduction of automatic sprinklers.

Without such careful tests these pipe systems would not have been properly proportioned, with the result that some parts would be without water; while others would get too much, as the supply pipes might have been too small and the equipments would have failed.

As mills became larger and concentrated values greater, better protection was needed. Ingenious minds had been working on the problem, and in about 1875 the first automatic sprinkler was developed in shape suitable for general use. This device has revolutionized the whole science of fire protection, and is the main instument which has made it possible to control the fire hazard within the limits which are now possible.

In the automatic sprinkler there is an orifice of about ½-inch diameter normally closed by a valve which is held to its seat by an arrangement of levers, links or struts which are held together by a fusible solder, the ordinary type melting at a temperature of about 160 deg. F. These sprinklers are placed over the ceilings of the rooms to be protected, with a head for about every 80 or 100 square feet of area, and water is supplied to them by pipes arranged much as in the old perforated pipe systems. On the occurrence of fire the temperature near the ceiling rises, one or more sprinklers open and deluge that particular section where the fire is.

The great points of advantage which the automatic sprinklers possess over all other means of fire fighting are, that they are on duty every hour of the day, and every day in the year, the heads which open are those located just where the fire is, the open heads can operate regardless of smoke or other conditions which would make it difficult for men to reach the seat of the fire. Such protection can cover every nook and corner of a plant and insure that fire starting at any point will be almost instantly met with such a downpour of water as to either extinguish it entirely or hold it in check within a small area until the last vestige is extinguished by the fire brigade.

The problem of devising and constructing automatic sprinklers has required much careful scientific work. The conditions are difficult. The device must be simple, and rugged, but such that it can remain in repose for years and then respond within 30 to 50 seconds where the temperature around them rises to the melting point of the solder, and yet withstand the ordinary tendencies to corrosion and the usual atmospheric changes. To accomplish this has proved no simple task, and many hundreds of patterns have been offered, though there are to-day but six to ten heads which are commonly used. Much very careful laboratory work has been necessary in testing sprinklers. It was of the first importance to be sure that a sprinkler head would be operative after years of standing; again, it was essential that it should not weaken by age and open when there was no fire, causing water damage. Time tests were devised in which sprinklers are kept under excessive load in order to determine in a few months the probable effect of years of use. Heads are artificially corroded to obtain a measure of their probable susceptibility to impairment under everyday use.

The first idea was that but a few sprinklers would ever be called upon at a time and that if these did not control a fire, other means must be used. Experience, however, soon showed that sprinklers could do a larger work, and that if supplied with ample water they could protect very large areas. In cases where buildings equipped with sprinklers were attacked by severe fires on the outside, flames were driven back by the water from the sprinklers, and the protected building was saved with practically no damage other than that from water. This at once showed the need of providing pipe sizes which would be ample to bring water to all the sprinklers which might open in any case. To determine this wisely very elaborate tests were made, in which the friction loss in pipes of different sizes used in sprinkler work was determined, as well as the friction loss in various types of fittings. This experimental work was carried on for months under the direction of men, practically all of whom had had technical education. From the data obtained schedules were made, pipe sizes determined, and the whole arrangement of sprinkler systems put on a sound basis which has now become the universal standard.

From the first there were careful inspections of the factory properties associated in this plan of fire study and loss sharing on a mutual basis. These brought to each owner the experience obtained over the whole field. The apparatus provided was tested, and, in the absence of any more exact method, it was a common practice in testing a fire pump, to throw streams over the mill tower, thus getting a rough estimate of the capacity and condition of the pump.

As more equipment was provided, better methods of testing became necessary. It was found that the ordinary tables for the discharge of water through nozzles were in error, and comprehensive tests were arranged under conditions where nozzles of different types could be compared, the height of streams noted, and the limits for varying pressures and different sizes of nozzles determined. At the same time the possibility of using better made nozzles for measuring water was demonstrated. These tests, carried on mainly by Technology men, resulted in the standard fire stream tables now universally used, and this work made a definite and valuable contribution to general hydraulic knowledge.

In these tests the friction loss in hose of different kinds was measured, and it was found that the smoothness of the rubber lining exerted a very great influence on the friction. With the ordinary fire stream, which was standardized as a flow of 250 gallons per minute, a smooth rubber lining caused a loss of about 14 pounds per 100 feet of length of hose. Other rubber linings, commonly used, caused a loss of over 25 pounds per 100 feet of length of hose. Thus the desirability of smooth linings was brought to the attention of hose manufacturers, improvements readily made, and the whole efficiency of fire hose very greatly increased. The standard tables made up from this data were put in such form that with the pressure at the hydrant, the length of hose, and the size of nozzle known, the amount of water discharged was given within the limits of a small percentage. This gave a convenient and accurate means of testing water-works systems and fire pumps, and marked a distinct advance in the whole science of water measurement for such conditions.

After the very early plunger pumps, rotary pumps came into general use with water wheel drives Later,

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† Vice-President and Engineer, Arkwright Mutual Fire Insurance Company, Boston, Mass.

as steam became more common, steam fire pumps were installed and one of the first steps was to point out the need in fire pump service of making the steam cylinder larger than those commonly provided for service pumps, so that the low steam pressure used in those days could develop a high water pressure. As steam fire pumps became common, tests by inspectors showed many failures. Parts would break; pumps would be found rusted so that they could not be moved; steam ports and water passages were so small that the pumps frequently could not be driven under fire pressure at all to their rated capacity. The problem was studied, and with the co-operation of pump makers a special fire pump was developed, more rugged in design, all moving parts rust-proofed, and with water and steam pipes ample. The result was a thoroughly reliable fire fighting machine of large capacity. This is now the type of pump universally used in fire protection work, and known as the "Underwater."

In a similar way progressive ideas have been applied to rotary pumps and in later developments to the centrifugal pump, now coming somewhat into use for fire purposes. In the same spirit of thorough investigation, hose, play-pipes, hydrants, and the many other devices used for protection against the fire, have been studied. Specifications drawn on scientific lines have been developed and the whole subject brought to a thoroughly scientific basis.

In the early mills, pipes of small size were first carried from roof tanks and fire pumps to standpipes and yard hydrants. It was soon found that more water was needed and cases developed where, when the full capacity of the pumps was desired, it was found that the pipes were altogether too small to carry the water to the point where it was needed. This brought about a study of the lay-outs in all the protected factories and engineers employed by the associated factory owners, revised old lay-outs and made new ones. In this work good hydraulic knowledge is necessary, and the aim is to provide pipes of such size that the whole capacity of the water supply available may be concentrated at any point with but few pounds loss of pressure between the supply and delivery point. In this way is laid out the protective equipment for the mills included in this system, so that the greatest efficiency is obtained with proper regard for economy in outlay.

It is of the most vital importance that the good construction provided at the start and the strong protective equipment installed should be maintained at all times in the best condition. The inspection service which began in a small way has been extended with the growth of the protected plants until now every factory is regularly visited four times each year, and a large part of the men engaged in this work have had technical education, or good practical experience giving a parallel knowledge and an acquaintance with the technical problems constantly arising in our modern manufacturing plants. Careful reports are made on each plant as it is inspected, so that conditions throughout the whole field may be watched and the owner of each factory gets an estimate of the condition of his plant by different men looking from different viewpoints and bringing to him the experience from a very wide field.

Plans of the protected properties were made at first in very simple form, then later in more detail, showing the general characteristics of the buildings, the arrangement of occupancy and the protection. A general view in isometric is also added, which enables one at a glance to obtain a good idea of the relative height and location of the different buildings.

The above points, but briefly touched upon, are simply the main features in a broad development which has made the modern protected factory, with its many hazards, one of the safest fire risks known. The summation of these various lines of activity have made a system and created the specialty of fire protection engineering.

A few examples of typical cases may be of interest. In the great fire which destroyed a considerable section of Paterson, N. J., about ten years ago, the conflagration was for hours beyond control of the combined fire departments. The fire finally extended to a group of protected mills. The fire pumps in these mills were early put in operation and the mill fire brigades stood ready. As the conflagration approached the mills it was met, driven back, and stopped. The scientific methods of fire fighting which had been developed, had triumphed, and these protected properties sustained practically no damage, and actually checked the conflagration in this direction.

Fires often started from unknown sources, and there was a constant tendency to attribute them to ordinary causes, without thorough investigation. To such fires the spirit of scientific investigation was applied. It was found that many fires came from the use of oils which rapidly oxidized, causing spontaneous combustion. A large amount of work was done in this direction, and the analyses which proved the truth of this fact and suggested remedies were made by the Institute. Many fires resulted from hot bearings improperly lubricated. Lubricating oils were examined and tested to determine the friction of bearings lubricated with different kinds of oils. Very great differences were found, and study showed that oil could be obtained which would almost eliminate the danger from hot bearings and which at the same time would not be subject to spontaneous combustion. Thus a very troublesome class of fires was eliminated by systematic study.

Goods colored by certain dyes were found to be liable to spontaneous heating under some conditions, and fires once inexplicable were easily proved to be the result of this action. Remedies were applied, either by changing the method of dyeing, or the method of handling the stock so as to give a proper chance for airing and cooling, and this danger was practically eliminated.

The underlying principle in all of this work, be it an intricate problem or a very simple one, has been to intelligently and carefully ascertain all of the facts, using the best scientific knowledge available, and then, with the conditions fully known, to devise changes in methods or provide precautionary features to take care of the difficulties and to do this without throwing serious obstruction in the way of economical and rapid production. It is a work in which the knowledge and skill of the scientific man must be combined with good judgment and an appreciation of everyday business conditions, and there must be constant willingness to co-operate to the full extent with the practical manufacturer. When the work is conducted in this way the gain to the manufacturer in the prevention of fires, the quick controliing of such fires as occur, and the safeguarding of his business from troublesome, and perhaps fatal interruption by a severe fire is certainly of the very greatest benefit.

It was undoubtedly true that windows of this kind did not break out or crack as ordinary glass would probably have done to a greater or less extent. The point, however, is that in all this work the real facts must be absolutely ascertained if true conclusions are to be drawn, and this instance shows the work which the trained observer can do when taking time to study every condition, and when imbued with the spirit of thoroughness. It shows further the need of such observers if the real facts are to be certainly determined and the true conclusions drawn.

A diagram (Fig. 1) of fires which have occurred in the association of factories which have carried on this study of protection against fire, where the loss has been over $100,000, shows that such fires came along with considerable frequency in the early days, but that later, when automatic sprinklers were largely in use and other means of prevention and protection developed to a high state of efficiency, there was a marked lessening in the number of severe fires. This plotting, together with figures showing the growth in value of the factories thus operating, makes a graphic object lesson of the results accomplished by the application of scientific methods.

In another way the cost of fires (diagrammatically shown in Fig. 2) including the cost of carrying on this system of studying them and maintaining methods of protection is shown, covering a period of fifty years, by ten-year averages. This, though not made up from the whole field, is typical and fairly represents the result from all the factories co-operating in this study. This shows the constant reduction in cost with the improvements in methods of handling the fire hazard. It should be remembered that this has been accomplished despite the enormous increase in size of properties and the introduction of many new hazards.

In more recent years the ideas and possibilities developed in this special field of manufacturing plants

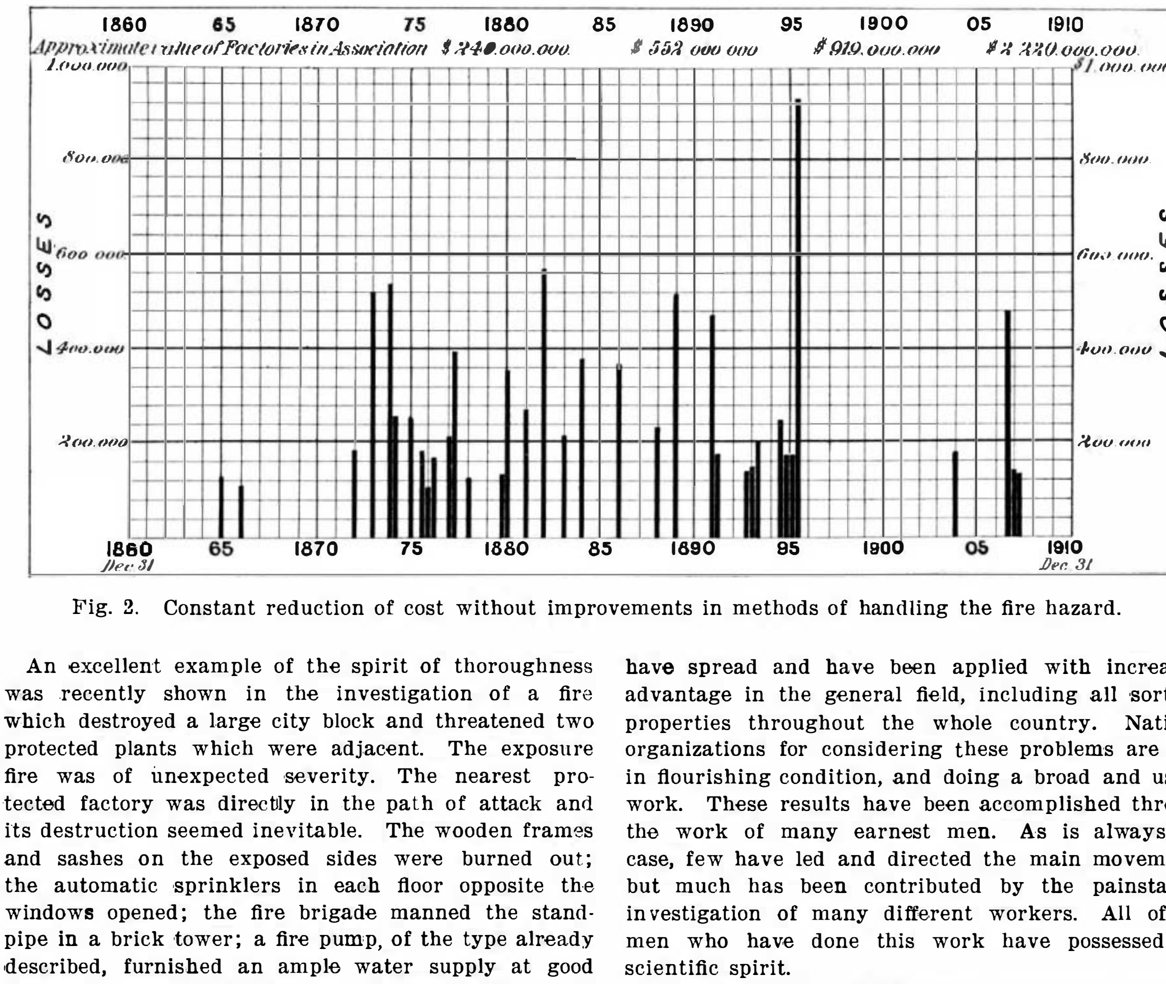

Fig. 2. Constant reduction of cost without improvements in methods of handling the fire hazard.

An excellent example of the spirit of thoroughness was recently shown in the investigation of a fire which destroyed a large city block and threatened two protected plants which were adjacent. The exposure fire was of unexpected severity. The nearest protected factory was directly in the path of attack and its destruction seemed inevitable. The wooden frames and sashes on the exposed sides were burned out; the automatic sprinklers in each floor opposite the windows opened; the fire brigade manned the standpipe in a brick tower; a fire pump, of the type already described, furnished an ample water supply at good pressure, and though the men were almost forced again and again to flee from the tower, they stood their ground, and the sprinklers, aided by the standpipe streams, kept the fire entirely out of the building, which without such equipment would surely have been quickly destroyed. The loss was moderate and confined almost entirely to the unavoidable wetting down.

An adjacent building was similarly protected, and all of the windows toward the fire were of wired glass in metal frames. Here also the private fire brigade did good service, helping out with hose streams any specially hard pressed point. When the fire was over many who examined the protected buildings gave credit to the wired glass and were inclined to attribute the saving of the large building almost entirely to it. Then a careful investigator with a desire to get at the exact truth, carefully studying the conditions, found that high wooden poles carrying electric wires, running up beside the building protected with the wired glass, were not charred. This evidence was at once conclusive that the severity of attack on the building with wired glass was much less than that on the other building, and that any attempt to draw from this incident a positive conclusion as to the resisting ability of such protected windows was erroneous.

have spread and have been applied with increasing advantage in the general field, including all sorts of properties throughout the whole country. National organizations for considering these problems are now in flourishing condition, and doing a broad and useful work. These results have been accomplished through the work of many earnest men. As is always the case, few have led and directed the main movements, but much has been contributed by the painstaking investigation of many different workers. All of the men who have done this work have possessed the scientific spirit.

The terrible loss of life which recently occurred in New York city and the loss of life and irreplaceable papers in the State Capitol at Albany could have been prevented by methods long since adopted in hundreds of manufacturing plants. But slowly does the scientific spirit penetrate the broader field where so many diverse interests are factors. With gain in the general breadth of view it is certain that these methods and this spirit will in the coming years be more fully recognized and will exert their beneficial influence throughout the whole country.

Trials of the "Danton"

THE new 20,000-ton battleship "Danton" of the French fleet, was recently put through a series of trials and the results were very good. On April 1st a third trial of 24 hours was made with all the furnaces and the Belleville boilers at work, and as the previous tests showed, the coal consumption per hour and per mile run was considerably lower than the contract figure. The amount of coal was 0.665 (long) tons instead of 0.685. It is to be noted that the "Danton" made three official tests within 8 days, which is somewhat remarkable. The ammunition quarters of the "Danton" and the "Voltaire" are cooled by the new L. Le Blanc refrigerating system.