

FIRE PREVENTION AND EXTINCTION: *

WITH SPECIAL REFERENCE TO THE CONDITIONS APPERTAINING IN INDIA.

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[Selected and Abridged for Publication.]

This Paper deals with methods adopted in modern practice for the prevention and extinction of fire. The fire loss per annum in the British Isles alone has been estimated to be about 2s. 3d. *per capita*. In the United States the annual loss by fire *per capita* is about 10s. 11d., and in Canada slightly more, these high figures being attributable to the large amount of timber used in, and the inferior construction of, buildings. This waste, which amounts to nearly 50 million pounds per annum, is now receiving the attention of the Legislative Departments.

Germany passed laws regulating the erection of buildings, storage of inflammable materials, installation of fire preventive devices, and moreover recognized the principle of "individual responsibility," and thereby reduced the annual loss *per capita* to 10d., a remarkably low figure when the huge manufactories and industrial centres are considered.

* This Paper was read and discussed at a Meeting of the Calcutta and District Section on 24th November 1915. A copy of the complete Paper may be borrowed from the Institution Library.

In France, where the fire loss *per capita* is not so low as in Germany, "individual responsibility" is also recognized. If a fire starts in any premises through carelessness or culpable fault, all damage to neighbouring property must be made good.

CAUSES AND PREVENTION OF OUTBREAK OF FIRE.

Prominence must be given to considering causes of fires, and means whereby such causes can be eliminated. Carelessness and ignorance are responsible for at least 85 per cent. of fires, and are most difficult to deal with when the class of labour in India is considered. Naked flames, such as oil lamps and candles, smoking, use of matches, etc., should be absolutely prohibited in or around buildings containing inflammable goods. Lights should be efficiently protected with wire or glass globes, especially where inflammable dusts are present. Friction is responsible for many fires in machinery; bearings should be frequently examined, and if inclined to heat, should be refitted, and properly lubricated with high flash-point lubricating oil. Hot-bearing indicators with alarm bell attached, which ring when a dangerous temperature is reached, are useful.

Gas Lighting.—Gas is comparatively safe, provided the burners are adequately protected, and not used when inflammable dusts are prevalent (unless dust-proof protection and anti-vibratory fittings are provided). Meters should be in well-ventilated positions, with an easily accessible cock to turn off the supply. All brackets should preferably be rigid, and the use of flexible tubing avoided. Gas-producers and attendant apparatus should be in a separate building in an open space.

Electric Lighting.—Properly installed systems are practically safe, and where fires due to electric lighting have occurred, the fault has usually been traced to poor workmanship and inferior materials, the use of which is unfortunately so large in Calcutta. Incandescent lamps generate a temperature sufficient to fire inflammable goods

such as celluloid, etc., and care should be used to prevent such materials coming into contact with incandescent bulbs. Flexible wiring is a prolific cause of fires, and should be avoided. Fittings connected by flexible wire should be without switches, so that the current is cut off from the flexible wire when the fitting is not in use. Where inflammable dusts or gases are present, dynamos, motors, resistances, etc., should be adequately protected, or situated in buildings away from the risk. The other fittings should be encased in dust-proof globes. Arc lamps should not be used in proximity to jute or cotton godowns, or where inflammable dust may accumulate. Electrical installations should be periodically examined by an expert, as the Indian climate rapidly deteriorates the insulation, as evidenced by the many recent fires in Calcutta due to this cause.

Improper Storage of Goods.—Many fires are caused by this. Acids require special care, and the carboys should be laid in lead-lined receptacles, which have a capacity greater than the contents of the carboy. The sun's rays have caused jute and rope fires, especially when focussed through windows, etc., which should be painted with at least one coat. Volatile liquids which give off inflammable vapours with a slight rise of temperature, require special care, as the vapour is liable to creep along the floor to a considerable distance until it comes into contact with a light.

Spontaneous Combustion.—Oily rags, waste, mops, sawdust, sweepings, metal turnings, filings, etc., have caused many fires spontaneously, and should be kept in metal receptacles, to be regularly emptied each night. Vegetable fibres are more dangerous than animal fibres, and oil (especially linseed) considerably hastens the action. Chemicals placed together will often fire spontaneously, and substances rich in oxygen should not be in contact with easily oxidizable materials. Chlorine gas in contact with turpentine or tarred ropes has caused fire; therefore care should be used in storing bleaching powder. Acids need particular care, nitric acid being especially dangerous when in contact with carbonaceous materials.

Inflammable Dusts.—The danger of fire and explosion due to these is shown by many explosions with great loss of life. Following two serious dust explosions in 1911, at a provender mill in Glasgow and an oilcake factory in Liverpool, Dr. R. V. Wheeler made tests with 66 samples of carbonaceous dusts collected from beams, ledges, or other projections. He divided the dusts into three classes :—

(1) Dusts which ignite and propagate flame readily, the source of heat to ignite them being small (e.g. a lighted match). These include sugar, dextrine (calcined farina), starch, cocoa, rice, meal, and sugar refuse, cork, unextracted and extracted soya bean, wood, flour, malt, oat husk, grain (flour mill), maize, tea, compound cake, grain (grain storage), rape-seed, cornflour (flour mill), chicory, briquette, gramophone records.

(2) Dusts readily ignited, but needing for the propagation of flame a source of heat of large size and high temperature (e.g. electric arc), or of long duration (e.g. flame of Bunsen burner). In this class are copal gum, leather, "dead" cork, cocoanut oil milling, rice milling, sawdust, castor oil, meal, oilcake, offal grinding (bran), grist milling, horn meal, mustard shoddy, and shellac composition.

(3) Dusts not propagating a flame under factory conditions, either because they do not easily form a cloud in the air, being contaminated with incombustible matter, or because the material does not burn rapidly enough. In this are organic ammonia, tobacco, spice milling, drug grinding, cotton seed, and soya bean, bonemeal, coal (foundry blacking), lamp black, sack cleaning, retort carbon, Russian rape-seed blacking, grain cleaning, charcoal (foundry blacking), brush carbon, stale coke, plumbago, bone, charcoal, and mineral and ivory black.

Dusts in (1) are arranged roughly in order of inflammability. Sugar, dextrine, starch, and cocoa are the most dangerous. In (2) the shoddy being of a fluffy nature, did not readily form a cloud, but contained enough fine material to render it dangerous when in bulk. Of (3) the first ten are all readily inflammable, but showed no signs of being able to propagate flame. Much depends

upon the fineness of the dusts. The lowest temperature at which sugar and dextrine dust will ignite is estimated to be 540° C. (1,004° F.), whilst the other inflammable dusts ignite at 600° to 650° (1,112° to 1,202° F.).

Petrol Storage.—Special regulations are necessary for the protection of garages, etc.

Defective Construction.—This has been the cause of many fires and also the means of fires spreading rapidly. In Calcutta, where heating is unnecessary, such fires are not so prevalent as in colder countries, but many do originate where chimney shafts are carried through floors or roofs and not properly protected.

PREVENTING THE SPREAD OF FIRE.

Unprotected iron girders and columns are to be strongly condemned; they quickly buckle or collapse, often pulling down walls and buildings. Steel and wrought-iron lose strength at high temperatures, and may depreciate 75 per cent. before red heat, so that buckling results, especially if no space is allowed for expansion. Cast-iron is particularly *bad*; it fails suddenly, especially if water is directed upon it when heated. All constructional iron work should be protected by at least 2½ to 3 inches of concrete.

A danger in India is the use of inferior mortar which disintegrates rapidly when exposed to heat. Good well-burnt bricks, well-bonded and flushed with mortar, form excellent walls, better than stone, which cracks when suddenly cooled and disintegrates when heated. Sandstone is best for withstanding fire, but is much inferior to brick walls. The fire-resistance of stone varies considerably with the method of quarrying, and granite can be quarried in such a way as to offer 100 per cent. more resistance.

Reinforced concrete is really good when proper precautions are taken in the preparation and use of the concrete, as, owing to the low thermal conductivity of good concrete, heat requires a considerable time to penetrate it to any degree.

Sprinklers.—Sprinklers are the best means of preventing serious fires, especially in warehouses containing jute, cotton, etc., and materials which produce a flash fire. By no other means can water be delivered at the seat of fire so accurately and promptly. The water in the sprinkler pipes, when in circulation, automatically rings an alarm bell and takes the place of a watchman. Sprinkler heads are made to operate at various temperatures, the most usual being 155° F. Where used over boilers, in dry kilns, etc., they operate at about 286° F., and in buildings where very high temperatures exist, the point is as high as 366° F.

The nozzle of a sprinkler head is usually about $\frac{1}{2}$ inch in diameter, and the discharge per head approximately 17 $\frac{1}{2}$ gallons per minute at 10 lb. pressure, 30 gallons at 30 lb., and 58 gallons at 100 lb. The efficiency at 50 lb. pressure is more than double that of the same sprinkler at 20 lb. per square inch. In buildings where there are acid and corrosive vapours, sprinkler heads should be examined frequently, as the fuse-bar may be coated over, and raise the temperature of operation.

Two independent water supplies for the sprinkler system are preferable, also an inlet to which the pumps of the Brigade can be attached. The bottom of elevated tanks should be at least 20 feet above the highest sprinkler head, and the supply pipe should project 4 inches into and above the bottom of the tank to be clear of sediment. A 10,000 gallon tank may be used for medium size plants.

Automatic Fire-Alarms.— Usually “detectors” are placed throughout a building at intervals, and connected to an indicator board, in its turn connected to the Fire Station. At a fixed temperature contact is made at the “detector” or thermostat, the position of which is shown on the indicator board. In the “Mercurial thermostat” a platinum wire is inserted in a tube similar to a barometer. The wire is placed at a point in the tube higher than that to which the mercury usually rises, and when an abnormal rise takes place, the alarm is electrically transmitted by the mercury-platinum contact. Metallic thermostats depend upon

the differing co-efficients of expansion of various metals. In one type of Automatic thermostat the expansion of air in a sealed chamber causes this to bulge and close the circuit. Some, such as the Fox-Pearson detector of Colonel Fox of the London Salvage Corps, are arranged so that a cautionary alarm is given to notify sudden rise of temperature, which, if maintained, develops into a fire call. In the May-Otway system the detectors notify a rise in temperature, being adjusted automatically by a compensating balance at the ordinary temperature. A detector adjusted for a 25° rise will give the alarm at 105° when the normal temperature is 80°. For climates with very variable temperatures, this system is worth consideration.

The Aero Fire Alarm on the pneumatic principle consists of a small copper pipe $\frac{1}{16}$ -inch diameter, the ends being carried to the indicator board. The detector consists of a flat circular chamber which bulges and forms electrical contact when the air in the copper tube expands. A valve allows for compensation for normal temperatures, thus any slow rise is automatically allowed for, but a sudden rise operates the system.

Fire-resisting Doors.—Iron and steel doors are not satisfactory, being liable to buckle badly in fires unless specially protected. A door by Messrs. Mather and Platt consists of three thicknesses of $\frac{7}{8}$ -inch boards at right angles laid diagonally, and completely encased in tinned steel or iron sheets 20 inches by 14 inches by 26 S.W.G. thick. The joints are lock-jointed and form a hermetically sealed casing. The door is hung on an inclined bar by two pulleys, so that it tends to remain closed.

Partitions.—Dividing walls of at least 9 inches brickwork form an excellent fire stop, and reinforced brickwork, 3 inches thick, with reinforced mesh in the horizontal joints laid in cement mortar, is also good.

Fire-resisting Floors.—Insurance Companies consider an approved fire-resisting floor to be equal to a fire wall, and the premiums are based accordingly. This should be noted when building.

Fire-resisting Glazing.—Two reports by the British Fire Prevention Committee show the utility of this. In one case the glazing when used vertically in windows withstood a temperature rising to 1,500° F. for 90 minutes followed by a stream from a fire-engine, and when used horizontally it withstood a similar temperature for one hour, followed by a similar jet of water. The maximum temperature attained was 1,600° F.

Protection of Openings in Walls.—Holes through which belts pass should be specially protected.

FIRE APPLIANCES SUITABLE FOR USE IN FACTORIES, MILLS, ETC.

Buckets.—Buckets filled with water or sand have the advantage of combining some efficiency with considerable economy, and are necessary to all installations, and in many risks are sufficient in themselves. An official should be held responsible that all buckets are kept filled, and that none are missing. It is a good plan to red paint the wall behind the positions of the buckets or other portable appliances to enable an Inspector to see at a glance whether they are in their places. It is found that fire-buckets are often used for purposes other than fire-extinguishing, *e.g.* window-cleaning, etc., and not replaced. Therefore all *fire*-buckets are better to have rounded or conical bottoms, so that they must remain in their proper places. But to reach a fire a small jet, if available, is better; therefore for every set of buckets a small double-acting hand-pump should be provided. By means of a stirrup one man can work the pump whilst directing a continuous stream of water.

Corridor Pumps.—These are tanks fitted with pumps and mounted on wheels, and hold about 30 gallons of water; the pump can project a small stream about 30 to 40 feet.

Chemical Fire Extinguishers.—There are many efficient types available for attacking a fire in its early stages; they combine the double effect of water and of carbon dioxide and salts. The general

principle is the generation of CO_2 by the combination of alkali (usually bi-carbonate of soda) with an acid (usually sulphuric). The alkali is mixed with water in the cylinder, and rapid generation of the CO_2 causes a pressure which expels the contents in a stream to a distance of 15 feet to 20 feet. Theoretically 1 lb. of bicarbonate of soda requires $9\frac{1}{2}$ oz. of sulphuric acid to liberate all the gas, but it is not advisable to use so much. The maximum quantity of acid per 1 lb. of bicarbonate should not exceed 6 oz., and about $\frac{3}{4}$ lb. of bicarbonate is required for 2 gallons of water. In most cases the acid is contained in hermetically sealed glass bottles, which are broken as required either by a plunger or by concussion. In others the acid is in a lead bottle sealed with a lead ball, such that when the extinguisher is inverted the ball drops and the acid is liberated. In others the acid bottle is sealed with a thin sheet of lead held in place by a screw collar, the acid being liberated by puncturing the sheet with a pricker. If the bottle is not hermetically sealed, there is danger that the sulphuric acid may combine with moisture, and if it is left unattended too long, the acid becomes weak and useless. The acid also combines with the alkali in the water generating CO_2 , so that if the outlet of the extinguisher is closed an explosion may result.

Portable Fire Extinguishers should be tested to 350 lb. per square inch, and the capacity should not exceed 3 gallons or be less than 1 gallon.

Chemical Machines, etc.—These are specially for dealing with fires of volatile liquids and electric arcs. One containing carbon tetrachloride having SO_2 and CO_2 gases in solution has been thoroughly tested by the British Fire Prevention Committee. The contents when expelled extinguished an arc of 250 amperes at 200 volts. In tests on burning petrol, success was obtained in cases where the fumes could be collected and thus exclude oxygen from the fire.

Sawdust.—Sawdust as a fire extinguisher has advantages over sand, because of its blanketing action. Sand, being heavy, sinks to

the bottom, but sawdust floats on the top and excludes the oxygen. Moreover, sand gets into the bearings of machinery. Its efficiency is greatly increased by adding 10 lb. of bicarbonate of soda to one bushel of sawdust. An addition of 10 per cent. of iron ore prevents the bicarbonate of soda from caking. Dry sawdust is as efficient as damp sawdust; the latter should not be stored owing to the possibility of spontaneous combustion.

Bunker Fires.—For the prevention of bunker fires in ships, Professor Vivian Lewis suggested that cylinders containing highly compressed CO_2 gas be inserted into the coal, the cylinders to be fitted with fusible plugs, fusing at a comparatively low temperature. Before any accumulated heat becomes dangerous, the gas would be rapidly liberated and cool the coal. Should a fire have started, the gas would extinguish it. This principle could be applied to jute and cotton godowns.

HYDRANT SERVICES.

A vital point in successful fire-fighting is to have sufficient pressure at the nozzles. The following are the maximum pressures that can be used efficiently with nozzles of various diameters:—

Diameter of nozzles . .	$\frac{1}{2}$ inch.	$\frac{5}{8}$ inch.	$\frac{3}{4}$ inch.	$\frac{7}{8}$ inch.	1 inch.
Maximum pressure that can be used with advantage . }	lb. 70	lb. 87	lb.* 104	lb. 121	lb. 139

More efficient work can be done with one stream at good pressure than with several jets at low pressure, at the same time unnecessary water damage is avoided.

Where the supply is from gravity tanks, there is often difficulty in obtaining sufficient head for the hydrants on the upper floors; this may be overcome by installing "Augmentor" pumps in the mains where the pressure is low, worked by hand or power.

The size of the mains depends upon the length, number of outlets, quantity of water required, etc., but 4 inches should be the minimum diameter with 3-inch offsets for connections to hydrant valves. A good plan is to lay the mains completely round a building, and it should be fed by two supply pipes from the pump. Valves should be fixed at intervals, so that should the main burst or be damaged this portion can be isolated without interfering with the whole service. When valves are not provided it is well to have at least two plugs of wood available, so that the broken ends of a main can be quickly and securely plugged. With hydrants and fittings simplicity and speed in getting to work are the important features.

Unlined canvas hose $2\frac{3}{4}$ inches in diameter is very satisfactory, but where water may cause damage by sweating through the canvas before this has expanded, hose lined with rubber can be used. Nozzle orifices usually vary from $\frac{1}{2}$ inch to 1 inch in diameter. Care should be taken that they are not damaged, and that the orifice is a perfect circle, for the slightest flaw causes the jet to break into spray, thus considerably reducing its value.

FIRE BRIGADE APPLIANCES.

A "First Aid Appliance" consists of a motor chassis of about 14-20 h.p., on which is mounted a cylinder containing about 50 gallons of water, connected to which is a carboy of highly-compressed CO_2 gas. This provides the pressure for expelling the water through a reel and hose. The jet is immediately available on arrival at the fire, and the crew get to work in a few seconds. The nozzle orifice of these machines is about $\frac{1}{2}$ inch in diameter, and the quantity of water is sufficient to extinguish a very large percentage of fires completely, without the aid of the pumps of the more powerful machines. "First Aid Appliances" often carry hook-ladders and ropes for rescue work, also gear to get to work from street hydrants.

Efficient respirators are of two classes, the "Self-contained Breathing Apparatus" and "Smoke Helmets (Bellows type)." The

former renders a man independent of the outer atmosphere. On the fireman's back are two cylinders of oxygen, and in front is a regenerating bag. A mask is fitted over the nose and mouth, and is connected to the regenerating bag by two tubes fitted with valves, one to allow the breath to enter the bag without returning, and the other *vice versa*. As the man exhales, the breath passes through caustic potash in the bag; this extracts the CO_2 from the breath. At a point near the inhaling tube the oxygen is admitted, kept at 30 per cent. by means of a regulator, and thus allows the fireman to work hard in comfort.

The Smoke Helmet consists of an asbestos helmet strengthened at the top to protect the head. Air is pumped into the helmet through specially armoured air-hose by double-acting bellows. No valves are fitted, as the air flowing into the helmet and escaping through a joint near the ears, effectively prevents the entry of smoke or foul gas. The radius of work is of course limited by the length of air-hose, which may become entangled in *débris*, or damaged by falling walls.

Almost all fire-escapes and ladders are telescopic, the extension being made by a hand-winch and steel rope. The height of the fire-escape when extended varies from about 35 to 70 feet. When carried on the rear of a motor chassis, unshipping can be effected in a very few seconds, and the escape can be got to work in considerably under one minute.

Turntable ladders are superseding wheeled fire-escapes; their advantages are that they can be used at almost any angle independent of the support of buildings, and they can also be swung round in any direction. Small space is required for working; a street wide enough for the chassis is sufficient for operating the ladders. A small two-cylinder CO_2 engine is used for extending the ladders to the full height of about 80 to 100 feet.

Buildings have to be scaled and rescues effected in positions where it is impossible to approach with turntable ladders or ordinary fire-escapes, such as the rear of buildings, which can only be reached through narrow passages. In such cases hook-ladders are used. These are usually made of best selected straight grained

English ash, and are about 13 feet 5 inches long. At the top is a steel hook 2 feet 2 inches long, with a 6-inch spur at the end. The under side of the hook consists of eight jagged teeth. The weight of ladder and hook complete is about 24 lb.

Turbine and reciprocating pumps are both used; the latter enables the water to be lifted from below the pump without priming, and the most effective high-pressure streams can be obtained at slow engine speed.

For the turbine pump an auxiliary priming pump, usually of the reciprocating type, is fitted, and is very efficient in getting the turbine to work.

The prevention of unnecessary water drainage is an aim of every well-trained fireman, and is facilitated by the use of turbine-pumps, since with these and hand-control nozzles, the branch-pipe man can turn off the water without having to communicate with the engineer at the pump. Although relief-valves are fitted on reciprocating pumps, making the use of hand-control nozzles possible, the method is not so satisfactory. Both types of pumps are driven by the propelling petrol engine, the turbine being connected direct to a shaft from the gear-box, and the reciprocating pump driven by pinions and a silent chain. The pump is usually placed at the rear of the chassis, but a recent petrol-driven engine has the pump just behind the driver's seat.

MOTOR GARAGES.

The Author concluded his Paper by suggesting various precautions for fire protection and prevention for motor cars and in garages, of which the following are the principal points. Petrol gas is $3\frac{1}{2}$ times heavier than air, and therefore the greatest danger is near the floor, or in motor pits, etc. The collection of vapour is difficult to detect and needs a constant look-out. All garages should be sufficiently ventilated. One pint of petrol will make 200 cubic feet of air highly explosive, the most dangerous proportion being one part of petrol vapour to eight parts of air. Petrol vapour creeps along the ground, and many fires and explosions

have been caused by it coming into contact with a light very many yards away from the point of leakage or escape from an open tank. Spilled petrol should be immediately wiped up. In fires the effect of water is to spread the flames, and sand or preferably sawdust should be used, the efficiency being greatly increased by adding 10 lb. of bi-carbonate of soda per bushel of sawdust.

One sawdust bin about 2 feet 6 inches by 1 foot 6 inches by 2 feet 3 inches high, with doors at the bottom extending the full length, should be added for every 1,000 square feet.
