SOME METHODS OF FIRE EXTINGUISHING

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Fires, that is to say the unintentional or undesired combustion of material, must have taken place in the earliest dawn of civilization or even before it. No doubt in the days of cave-man it was merely the accidental burning of dried grass and rushes laboriously collected for the purpose of becoming material for bedding etc., but as life became more complex and articles began to be made (often of wood or other combustible matter) and still more when tents and rude dwellings were constructed, fires became a matter of serious loss. Methods of extinction therefore would be sought, and it would soon be discovered that fires could be "smothered," could be beaten out, and could be "quenched" by means of water. Notwithstanding the advances made since these remote and far off days, the principles just mentioned form the basis of the action of almost all fire-extinguishing devices simple or complex in construction.

Excluding fires of a purely "chemical" nature, a fire is an exothermic oxidation by the air. It follows that a fire can be extinguished in two ways:—(*a*) by shutting off access of the air (smothering) and (*b*) by cooling the burning body down below its ignition point; (*b*) can be further sub-divided :—(i) by bringing a large volume of cold material into contact with it (*e.g.*, water); (ii) by breaking up the burning substance into a large number of small fragments (beating out).

WATER

Water was no doubt the first actual extinguishing agent to be used, its use for this being no doubt known from the dawn of human history. Water has many desirable properties (*a*) it is available in very large quantities often at no cost or negligible cost, (*b*) it is not corrosive, (*c*) its specific heat is high, (*d*) it is non-inflammable, (*e*) its boiling point is fairly low, so that its cooling effect from evaporation is considerable, but not so low as to be inconvenient in use and volatile at ordinary temperatures, (*f*) it has considerable "wetting" properties, (*g*) its vapours are non-toxic.

Water owes its extinguishing effect to its cooling effect and also when used from a jet to its breaking up and scattering effects. Time will not permit the tracing of the history of the use of water for fire extinguishing purposes, but it is probable that buckets were first used. These would, while having considerable extinguishing effect when used in frequent quantity (as in a human chain), have a limited range and little impact effect. Squirts therefore came into early use and you are doubtless familiar with old prints showing the use of such. The squirt was held by two men by the handles, while a third depressed the plunger. Later the squirt was converted into a nozzle of a force pump mounted on a wheeled trolley which also carried water tanks to supply the pump, which was worked by a double handle. Later leather hose was added, so that the engine did not require to be brought close to the fire. This developed into the "manual" fire engine, which continued in use till the close of the nineteenth century and indeed may possibly still be found here and there. The "manual" in about 1850—60 developed into the steam fire engine, and this into the petrol or diesel-engined pumps of today. The steam-engined pump is now almost obsolete, except in the form of marine fire floats.

Water is used in the form of steam, mainly on shipboard. In this form while there is still a cooling effect even in the case of super-heated steam, it acts largely by displacing the air. An interesting development of this is the use of steam under pressure into which is injected immediately before use water under pressure so that a mist of relatively low temperature is created. (G.P. 291,788.) So-called chemical extinguishers were naturally a development later to water-extinguishment.

Among the first purely "chemical" extinguishers to be used were "grenades," which consisted of glass balls or spheres similar to herring-net floats, which contained a solution of sodium bicarbonate; these were flung on to the fire, where they burst and liberated their contents. The principle is still used, liquids such as carbon tetrachloride being contained in the globes.

DRY-POWDER EXTINGUISHERS

These also soon came into use and are still used, the basis of most being bicarbonate of soda. To prevent caking other substances are added, such as sand. A very large number of substances have been patented as charges. The use of compounds that liberate gases other than CO_2 is claimed (*e.g.*, a mixture of sodium silicate, borax, microcosmic salt, and monosodium phosphate (U.S.P. 1,271,506). The action of these dry-powder extinguishers depends more on their adsorbent and smothering power, than on the extinguishing effect of the gases, and the fused salts are often intended to form a fire-proofing crust over the burning or burnt material. As an example of non-gas forming charge granulated cork treated with a saturated solution of sodium silicate has been patented. The use of dry-powder extinguishers is obviously confined to fires of such a nature that the apparatus can get sufficiently near to throw the contents on to the fire in sufficient extent to form the protective covering. In some cases, however, the contents are liberated by CO_2 under pressure, thus giving a greater range.

SODA-ACID EXTINGUISHERS

These were amongst the earliest to be introduced and are still very largely used. It is hardly necessary to mention the principle involved: the ejection of a jet of liquid by the mixing of an alkaline bicarbonate with an acid. Those normally in use are (1) the plunger type and (2) the turn-over type. In the plunger type the bicarbonate solution is contained in the body of the extinguisher, and the acid in a sealed glass container inside at the top. The depression of the plunger breaks the bottle and the CO_2 generated ejects the liquid at the nozzle. As this type is normally used in a vertical position it must be provided with a syphon tube reaching almost to the bottom. A drawback to this type is that if heat causes the air in the space to expand creeping may take place at the nozzle. This can be periodically pricked, but if neglected may clog it.

To get over this difficulty the turn-over type was introduced. In this case the acid is contained in a glass bottle which is closed by a loose-fitting lead stopper. Inverting the stopper causes it to fall out. The outlet tube does not of course need a syphon tube, but is placed at the top. If the fire is extinguished before the contents are used up, the extincteur can be placed upright when the CO_2 escapes and damage by water is reduced.

In these extinguishers it is of course the jet of liquid which acts as the extinguishing agent, the CO_2 being the propelling agent. The charges are adjusted so as to avoid excess acid being present in the mixed contents, but nevertheless some damage must inevitably be done to furniture, fabrics, etc. This, however, is better than having a serious fire! This damage can be lessened by the use of a solution of aluminium sulphate instead of H_2SO_4 as the acid charge. The extinguishers have to be strongly made, as they must stand a high test-pressure before being passed for use (350 lb.).

To prevent corrosion the steel used must be either plated with lead or coated with a lead-tin alloy, and great care must be taken to render this as impervious as possible. In making up the charges for the extinguishers, Hewlett has pointed out (Chem. & Ind., 1935, 1094) that water containing excessive amounts of chlorides, sulphates, ammonium salts, and organic acids (from peaty waters) should be avoided as hastening corrosion. In addition to the ordinary two-gallon sizes, large extinguishers, carried on hand-trollies, are made.

HALOGEN DERIVATIVES

Non-aqueous liquid fire extinguishers are required for certain purposes, among others, for dealing with electrical fires. We are practically confined to the use of organic substances. Most organic liquids are inflammable, and in practice the liquids ordinarily available for fire-extinguishing purposes are the halogen derivatives of the hydrocarbons. The number of such compounds is large, since both saturated and unsaturated, aliphatic and aromatic hydrocarbons are available. In addition to simple compounds, more complex bodies with two or more different halogens in the molecule are of course available. An almost infinite number of such compounds are in theory available. In practice, however, only a relatively small number of compounds are much in use, since they must be reasonably cheap to produce, and must be available in fairly large quantities. Carbon tetrachloride has been most used and is still the compound used in probably the greatest quantity. It is so well known that it is hardly necessary to discuss it at length. In addition to its comparative cheapness, it owes its use to a number of properties.

(*a*) Its vapour is non-inflammable.

(*b*) Its boiling point (76°—77° C.) is such that it vaporizes on coming into contact with hot surfaces.

(*c*) Its vapour-pressure in the container is not high, so that pressure containers are unnecessary. Some positive method of ejection is therefore required, such as a pump. While this adds to the complexity of the extinguisher, it enables the operator to stop and start it at will.

(*d*) The density of the vapour is high, 5½ times that of air, so that it tends to hang over a fire and exclude the air.

(*e*) It is a non-conductor and is thus available for electrical fires involving switch-boards etc.

(*f*) Being readily volatile and comparatively non-corrosive it does little damage to fabrics.

Carbon tetrachloride has a striking and cooling effect like water, but its main extinguishing effect is due to its blanketing properties. Its dielectric properties are such that it is stated to have been used on short circuits up to 200,000 volts. It is essential that no trace of water be permitted to be present in the liquid, not only on account of the risk of corrosion in the container, but also to prevent any impairment of its non-conducting properties.

Methyl bromide.—Methyl bromide is a product that has come fairly extensively into use in recent years. Being a bromine compound, it is rather more expensive to produce than carbon tetrachloride. A smaller concentration, however, is required in use.

Its B.P. is 4·5° C., so at ordinary temperatures it is under some pressure. This pressure is sufficient to eject the contents to a certain distance without the use of pumping gear, nitrogen or other inert gas being used, however, to increase the pressure in the sealed containers. The contents of the extinguisher are ejected when brought into use, so that a re-charge by the makers is necessary after use. The extinguishers can, however, be operated by one hand. The melting point is − 93° C, so that no anti-freeze compound is necessary. Its vapour density, as compared with air, is 3·27. Like carbon tetrachloride, it has high dielectric properties. The actual fire-extinguisher effect is rather greater than with carbon tetrachloride. It acts by cooling and blanketing.

In some methyl bromide extinguishers, the addition of other halogen derivatives to increase the distance of throw (such as pentachloro-ethene etc.) has been made. It is now, however, more often used in the pure state. Methyl bromide is extensively used in dealing with aircraft fires for which it is very useful, and is used also for dealing with car and motor-boat fires. Both portable and fixed installations are available. An interesting application is for small flare-ups in laboratories, or fires in industrial premises involving volatile liquids, *e.g.*, acetone for which it is in considerable use.

Very many mixtures of halogen derivatives have been patented, including fluorine compounds. These halogen compounds have a well marked effect in extinguishing that cannot be attributed to reduction of oxygen content, or to the specific heat of the compounds. Thus 5% of carbon tetrachloride vapour in the atmosphere is sufficient to extinguish flame, *i.e.*, a reduction of the oxygen content from 21% to 20%, and a smaller concentration still of methyl bromide.

CARBON DIOXIDE

The use of carbon dioxide for fire-extinction dates from the time that it has been available commercially in quantity. The fire-extinguishing effect of CO_2 is mainly that of reducing the oxygen content of the atmosphere, though when the extinguisher is used to throw "snow" on a burning object it has naturally a cooling effect also. It is contained, of course, as liquid in cylinders. The vapour pressure of liquid CO_2 in cylinders at 15° C. is 735 lb. As a safeguard bursting discs are fitted to the cylinders to guard against a dangerous increase in pressure when exposed to higher temperatures.

The advantages of CO_2 are: Great di-electric strength (equal to the air), non-toxicity in small to moderate concentrations, quick dissipation after extinction of fire, but little corrosive effect either on objects or cylinder cheapness.

A disadvantage is: The weight of the outfit limits its portability (a pressure gauge is naturally useless for telling when a cylinder is nearing exhaustion). The cylinder must be weighed at regular intervals to detect possible leaks from valves (six months), though with modern design there are very few places where leaks can take place. The cylinders must be arranged so that gas cannot be discharged through the nozzle, as if so, the nozzles would choke through deposition of solid. This is prevented by causing the liquid to be delivered to the nozzle by a syphon tube reaching to the bottom of the cylinder and by a valve giving its full opening almost at once. The orifice of the valves is such that the liquid gasifies on leaving the cylinder and then condenses to a snow or mist, through the discharge horn. The bursting disc in some types can be perforated by the discharge lever. That is to say the lever cuts through the disc like a tin-opener. Portable outfits can be obtained, in which the cylinders are mounted on trollies or trailers.

It is hardly necessary to say that reasonable care must be used by an operator using in a confined space any extinguisher producing gas or vapour, such as CO_2 or the halogen compounds etc.

It is, however, as might be expected, in fixed installations that CO_2 finds its greatest usefulness. The 50-lb. (*i.e.*, 50 lb. weight of CO_2) is a convenient size for batteries of fixed installations. Their number must be such that the gas projected will be sufficient to render the atmosphere of the protected space incapable of supporting combustion, plus a certain margin. Their operation can be by hand or automatic and delayed action can be arranged for. These fixed installations are very largely used in electric generating stations. When enclosed gear is being used, the atmosphere inside the enclosed space can be very quickly flooded with CO_2 gas. Ships' holds can be protected. This is frequently done in conjunction with a smoke-detector outfit. CO_2 can be discharged from control valves operated in the chart-room into any hold affected.

The amount of CO_2 required runs up to 25% of the air-space, with ordinary combustibles. It should be noted that certain metals (magnesium and the alkalis) will burn in CO_2.

FOAM SYSTEMS

The use of a froth or foam for smothering fires has been known for some considerable time. Laurent of St. Petersburg and Urquhart in U.S.A. in 1904, first made use of the method.* Laurent used two solutions A and B, which on reacting produced bubbles of CO_2 in the form of a froth. He emptied barrels of each of the solutions on to a pit of burning naphtha. The success of such experiments led to the eventual large use some years after of installations for combating oil fires.

The solution A (acid) of the "two solution" foam extinguisher consists of an aqueous solution of aluminium sulphate or ferric aluminium sulphate and solution "B" bicarbonate of soda, with a certain proportion of carbonate of soda if the ferric salt is used, together with a foam stabilizer. An extremely large number of substances have been patented as stabilizers, but saponine or liquorice extract, particularly the former, have been most largely used. The volume of foam produced amounts to about 8% of the mixed solutions. The foam of course acts as a blanket. When foam is first applied (say to an oil fire), the heat of the fire is sufficient to expand the gas in the bubbles and thus to burst them. The liberated gas exerts a partial extinguishing effect, which brings about a certain fall in temperature and consequent reduction in the rate of the evaporation of the unburnt oil, which in turn brings about a reduction in the size of the flames. As more and more foam is poured on the fire, the extinguishing effect of the foam gradually overcomes the expansion and bursting effect of the heat, the upper layers of the foam being protected from the direct heat of the fire by a layer of partially destroyed foam underneath. Once a complete layer of unbroken foam is permanently formed over the surface of the oil, combustion ceases.

Oil tank farms can be protected by fixed installations, the two solutions being kept dissolved in tanks for the purpose. A system of mains is lead through the farm and at each tank, pipes of each solution are led side by side up to the top where a mixing chamber is situated.

Small portable units are available which operate after the manner of the soda-acid types. The outer container contains the alkaline solution and stabilizer and the inner the acid. A valve at the top seals both containers and prevents accidental mixing of the

* H. S. Simonis, Proc. Inst. Fire Eng., 1933, 47.

contents. When the extinguisher is to be brought into use, the valve is released, the apparatus inverted and the two solutions mix. The contents are expelled by the internal pressure, it being remembered that in this case we have not both a gas produced over a liquid, but a single content, the foam. A later development was the single powder system or continuous foam generator. If a solid acid and solid alkali be used and the mixture fed into a stream of water, foam will be developed after the manner of the familiar sherbet of our childhood years and the health salts of our riper years.

The powder is fed into the water-line by a hopper, the former being constricted at the point of attachment. The flow of water and discharge of powder are controlled by valves. As there are optimum conditions for the operation of such a system, it is necessary that the ratio of water to powder be accurately controllable. Too rapid a flow of water will cause liquid to mingle with the foam, while too slow a flow will be wasteful of powder. A normal order of water pressure would be, say, 100 lb. It is necessary to arrange for this fairly high pressure in order to avoid back pressure from the development of the gas. A certain length of piping is necessary for the reaction between powder and water to take place, having regard to the velocity of the water through the pipe. Too great a length on the other hand must be avoided, as the friction of the passage of the foam will tend to break down the bubbles of the lather. When a long length of outlet piping cannot be avoided in an installation protecting say a tank farm, a two-powder continuous generator can be used.

In this system the inlet and outlet pipings and hoppers are duplicated up to a point in the system, solutions of course instead of foam being conveyed from the respective hoppers. At this point in the system, there is situated a mixing chamber, which would normally be at the top of a tank, and the foam is produced here. In large installations where the powder or powders cannot be fed by hand, it is possible to arrange for the powder to be fed automatically in such a way that when the back pressure in the outlet side reaches a certain figure the supply of powder is shut off.

Lower pressures than 100 lb. can be used provided the dimensions of the apparatus are appropriately proportioned. For given dimensions the greater the pressure the greater the rate of supply of foam. Some 100 to 150 lb. per 100 gallons of water is required. When a flexible hose is being used, the hopper is put into the branch pipe between the fire-pump and the nozzle.

Portable and semi-portable generators are made for this type of extinguisher. The body is cylindrical and heavily-built. It is double-walled and into the annular space between the walls the " cartridge " containing the dry powder is fitted. A tight-fitting lid is heavily clamped on with a screw-down lever; the water inlet from the mains or from a pumped supply is situated near the top, and from this inlet an internal pipe proceeds fitted with jets which strike the powder at an angle. The foam is emitted through a fairly wide orifice from whence it is conveyed by hose. Water pressures down to 30 lb. can be used. If possible, in order to provide the maximum protection, such extinguishers should be provided in pairs, as otherwise in the event of the fire not being extinguished by one extincteur, unlike the hopper or hose system already mentioned, a delay would occur during re-charging. With two available, a continuous flow is assured, the first being re-charged while the second is being brought into operation.

AIR FOAM

About twelve years ago what is known as " mechanical foam " was introduced. In this system all chemicals but the foam stabilizer are dispensed with. In " chemical foam " the CO_2 produced acts primarily as a foam or bubble producer, and only secondarily as an extinguishing agent. We have really an analagous state of matters to the familiar soda-acid extinguisher, where the CO_2 is merely a propulsive agent. As the foam in " chemical foam " is some eight times the volume of the liquid water in the ingredients, it will be evident that in the incipient and early stages of the application of foam to a fire, the water vapour is present in much greater volume than the CO_2, and once the blanket has been completed, the fire is being smothered by its own products of combustion. It was thus found that the gas in the foam might be air. There is a saving of cost with mechanical foam. Thus with mechanical foam 2 lb. of foam stabilizer and 100 gallons of water will give 1000 gallons of foam. On the other hand, some form of mechanical beater, at least in fixed installations will ordinarily be necessary.

A device used in brigade work is known as the " foam-making branch pipe." In this apparatus a solution of foam-compound or stabilizer is fed into the water stream. There is a space at the back of the nozzle through which air is drawn, somewhat after the manner of a filter-pump. The result is that foam issues from the nozzle of the branch-pipe. Suitable valves control the supply of stabilizer and water, so that the consistency of the foam can be varied at will. The foam-compound which is in small volume compared with the water, can be carried on the back of the fireman, in a knapsack, and can be replenished as desired. In conjunction with a pump, the system can be used in fixed installations. The compound is fed into the water stream at the suction side of the pump, and the branch-pipe fixed at suitable places. One useful point about this system is that water or foam can be ejected at will.

" XAUST-SUDS "

An ingenious device known as " Xaust-suds " is on the market. In this, instead of air, the exhaust gas of a petrol engine is made use of. This is made use of with water from the mains in the usual way, the foam compound being fed into the water by means of a small pump, usually electrically-driven from an ordinary car battery. A reducing valve is incorporated in the water inlet to reduce the pressure to 10 lb. so that the exhaust gases can be used. As exhaust gases are not always available in sufficient quantity, a modification of the system is in use whereby a smaller petrol engine is made to operate an air pump, so that air is used instead of exhaust gases. The apparatus can be made portable by mounting it on a trolley, and an ordinary fire pump can be incorporated if desired in addition, so that either foam or water can be ejected.

"MULSIFYRE" SYSTEM

Many systems have been devised for extinguishing oil fires. This is due to: (*a*) the great damage that may be done by a fire, (*b*) the highly inflammable nature of the oils, (*c*) the large quantities stored. Foam systems have been mentioned, and those making use of CO_2. These act by smothering the fire by means of a blanket. Another system with which some here may not be familiar is that known as the "Mulsifyre" system. The term is of course a registered trade name. In this system, a temporary emulsion of oil and water is produced on the surface of the burning liquid. A number of nozzles with fine jets are located in water mains situated over the tanks to be protected and the fire is extinguished by causing jets of water to impinge on the burning surface, producing a temporary emulsion.

Oil fires are essentially vapour fires, the heated oil giving off volumes of vapour which burn in the air over the surface. Light hydrocarbons such as motor-spirit give off large quantities of vapour at ordinary temperatures, but heavier oils such as kerosene, gas oil, and fuel oils require a certain amount of heat to be applied. This heat may not at first in the case of a large tank extend to more than the surface layers of the liquid, but the heat of the burning vapour will cause the fire to get larger and larger, owing to more and more vapour being driven off. It is only rarely in the case of large tanks that the liquid will actually boil, at any rate in its incipient stages, as there is of course a cooling effect produced by evaporation at the same time. This is fortunate and renders oil fires more easy to attack than they would otherwise be.

The emulsion in question consists of globules of oil separated by films of water. In the writer's opinion, the extinguishing effect is at the onset due to the large volume of steam given off from the surface, together with that produced along with CO_2 from the burning oil. Once a layer of emulsion is formed, however, the water film has a trapping and cooling effect on the oil vapour. An emulsion composed of two-thirds petrol and one-third water will not burn. The emulsion, if it can strictly be so called, is transient and breaks up into its constituents on standing. This is an advantage, as the oil is not lost but can be recovered.

A pressure supply of water is required, the majority of oils requiring a pressure of 40 lb. For light hydrocarbons such as motor-spirit a higher pressure is necessary. As can be imagined, a petrol-water emulsion is more transient than one with a heavy oil. Installations are in use for vegetable oils as well as for hydrocarbons. The installations are usually combined with an automatic sprinkler system, *i.e.*, the jets are brought into operation automatically with rise in temperature, and by a suitable arrangement of valves, any desired number of heads can be made to open by the fracture of one sprinkler bulb. The boiler-room of ships can also be protected and sea-water can be used as well as fresh.

A very important application of this system is the protection of power stations, where large quantities of oil are used in transformers, switch gear, etc. On first consideration it would appear extremely unlikely that water in any form would be a suitable protecting or extinguishing agent, but if the nozzles are so placed that the jet has broken up into discrete drops before striking the oil, although to the eye the stream may appear continuous, it is a non-conductor. Each drop is insulated from its fellows by the air, *i.e.*, conduction does not take place back along the jet so long as there is not unbroken contact anywhere of liquid water.

SPRINKLERS

The sprinkler system of fire-protection is one of the most important of all, and is so well known that a description of the principles involved is hardly necessary. At a comparatively early date what might be termed the germ of the idea engaged attention and in 1723 Godfrey invented a system whereby a cask of fire-extinguishing solution was brought into action by gunpowder and a system of fuses. In 1809 Congreve produced a system of valves or sprayers brought into action by combustible cords. Little success was naturally achieved by these early crude devices, but in 1864 Harrison, and in 1874 Parmelee, in America, introduced practical systems which were improved in 1883 by Grinell, whose name is still borne by a very well-known sprinkler system. The heads on the earlier systems were brought into use by the melting of fusible joints. Later the fusible joint was replaced by struts held together by a fusible solder.

The modern valve consists of a glass ball closing a circular orifice cut in a metal diaphragm over the orifice of the pipe. The ball is kept in position by three vertical struts, soldered together by fusible metal; water pressure keeps the valve tight; rise in temperature causes the joints to be knocked away by the fusing of the solder. Water rushing from the valve impinges on a deflector and the water rebounds in the form of an umbrella-shaped spray.

An improved type of head is now in use. A quartzoid bulb takes the place of the struts. The bulb is filled with a liquid and a bubble of gas. With rise in temperature, pressure causes the solution of the gas; when the liquid entirely fills the bulb, pressure rises rapidly, and eventually the bulb is shattered, releasing the valve. The construction of the bulb is such that it flies into small pieces which are immediately knocked aside, and it is strong enough to withstand the pressure of water in the mains. Different liquids are in use for the different temperatures of operation required. The liquids do not freeze at temperatures ordinarily encountered.

When a sprinkler system is installed, two sources of water supplies are necessary in order to guard against the possibility of interruption or failure of one of them. These will ordinarily be (*a*) the town mains and (*b*) a roof tank in the building, with a head 15/50 above that of the sprinkler lines. Pressure tanks and pump supplies are also used. The "riser" to the tank can be fitted with connexions for fire hose if necessary, as this is sometimes useful.

ALARM VALVES, STOP VALVES

The provision of an automatic alarm valve is an essential part of a sprinkler system, because when a fire is immediately extinguished by the opening of one or more heads, unnecessary water damage would result if the supply was not shut off. A common and satisfactory device is the fitting of a non-return valve in the pipe system which rises off its seat readily when a head opens. This is made to by-pass a little water into a chamber, and the weight of this water can be made to operate an electric circuit fitted with an alarm gong. Stop valves are fitted so that the water supply can be turned off as soon as inspection shows that the fire is out. Whenever a head has operated it must be immediately replaced and the system restored to normal.

In cold climates or where there would be a risk of the water in the pipe freezing, the "dry-pipe" system must be used. The lines of the heads are filled with air under pressure, and such lines are connected to the water supply by means of a "dry valve," which operates when the air pressure is released by the opening of a head, thus admitting water into the pipe lines. There is the objection that a slight time lag occurs, so that it is necessary to limit the number of heads served by each dry valve. The wet system is the one normally in use, but a dual system can be used, the pipes being wet in summer and dry in winter.

Whenever sprinklers are installed, only those portions of the risk, if any, permitted by the insurance companies' regulations may be left unprotected. The sprinkler system has the great advantage that it gives constant and permanent protection, applicable to general premises and comparable, say, to the protection of oil tank farms by many devices that have been mentioned. The chances of a fire getting away are small, one well-known firm of sprinkler makers claiming an average of £60 per fire. The drawback is of course that compared with a supply of portable apparatus the initial cost is high, but against this can be offset the rebate on insurance premiums amounting to as much as 70% in very hazardous risks. Before rebates can be granted, the installations must conform to the detailed regulations laid down by the insurance companies.

The application of extinguishing systems to A.R.P. work has naturally now been engaging much attention particularly for the extinguishing of what may be termed the "ordinary" small thermite bomb. Extinction is most difficult while the actual thermite charge is going off, and more easy after this has been exhausted and the magnesium casing is burning. Water, if merely thrown on, will feed the fire, but water from a jet of sufficient force will extinguish it. It is said that an ordinary two-gallon soda-acid extinguisher can do so. The writer has not seen such tried, but there is undoubtedly a considerable body of evidence that this is so. Whatever other systems are installed a supply of soda-acids should be kept on hand. Once the bomb has been used up or extinguished, the fire has become an ordinary one and can be tackled with ordinary appliances, and here fixed installations such as the sprinkler or other types are particularly useful. Whenever a water system is fitted, a duplicate supply completely separate from the mains is essential. During a raid the public mains, apart from the risk of their being cut, would have a very severe strain thrown upon them, and pressure would in all probability be low.

This duplicate supply can take the form of an air-lift to the usual elevated tank, the pumps for such being driven by diesel engines, and the water supplied from tanks or reservoirs. A mill-pond, a canal or river in the proximity of the works is a particular treasure, and where the distance is not too great, the laying of service mains or pipes to such is well worth considering and that not merely for A.R.P. It renders it possible to use a fire-pump and hose, in addition to a fixed installation. A.R.P. may be a blessing in disguise (very much disguised it must be confessed) if it draws attention to the need of adequate fire protection.

Even the very far from complete catalogue given in this paper shows that the user has a bewildering array of appliances at his disposal. The particular type he will select as most suited to his requirements must depend on numerous factors: the construction of his buildings, the nature of his processes, the materials he stores, the proximity or otherwise of an adequate water supply, and perhaps most important of all his distance from a public fire-brigade. It is perhaps unnecessary to add that rebates on fire insurance premiums are granted for approved devices and are of course essential for certain risks. However efficient the fire protection of any premises may be considered, if an actual outbreak of fire occurs while anyone is on the spot, and the premises are in an area served by a public brigade, a call should be put through at once, without waiting to see whether the equipment at hand will deal with it. Never reverse this order. It may seem somewhat unnecessary to stress this, but there is always the first inclination to tackle the fire oneself, especially if the fire squad has been effectively trained, and the appliances are known to be efficient. But a brigade exists for the service of its area. The fire may be, and usually will be extinguished before the brigade arrives, but not always, so make assurance doubly sure.

These notes have been rather in the nature of a catalogue, and the author is conscious that a number of important devices have not been touched on, but the object was to bring to your notice in a limited time as many as possible of those with which the author was most familiar. Many types are made by a number of different firms, often with special modifications which may happen to supply the answer to your particular problem.

The writer desires to express his thanks to the many firms of fire-appliance manufacturers who kindly supplied slides, diagrams, literature and catalogues, particularly to Messrs. Mather and Platt, Ltd., The Pyrene Co., Ltd., and the National Fire Protection Co., Ltd. He also desires to express his thanks to Mr. J. Sandilands, F.I.C., of the Heriot-Watt College, Edinburgh, for kindly preparing a number of lantern slides.