"BOOKS" of the
BRITISH FIRE PREVENTION COMMITTEE.—No. 201
Edited by the Executive.

HOW TO DEAL WITH DIFFERENT KINDS OF FIRES

SOME HINTS

BY

SIDNEY G. GAMBLE

F.S.I., A.M.Inst.C.E.

(Late London Fire Brigade, 1898–1918.)

LONDON, 1918

PUBLISHED AT THE OFFICES OF
THE BRITISH FIRE PREVENTION COMMITTEE
(Founded 1897—Incorporated 1899),
8 WATERLOO PLACE, PALL MALL, S.W. 1.

F. J. Mortimer, F.R.P.S.

SIDNEY G. GAMBLE,
F.S.I., A.M.Inst.C.E.
(*Late London Fire Brigade, 1892–1918.*)

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Three Shillings and Sixpence.

OBJECTS OF THE COMMITTEE.

The main objects of the Committee are:

To direct attention to the urgent need for increased protection of life and property from fire by the adoption of preventive measures.

To use its influence in every direction towards minimizing the possibilities and dangers of fire.

To bring together those scientifically interested in the subject of Fire Prevention.

To arrange periodical meetings for the discussion of practical questions bearing on the same.

To establish a reading-room, library, and collections for purposes of research, and for supplying recent and authentic information on the subject of Fire Prevention.

To publish from time to time papers specially prepared for the Committee, together with records, extracts, and translations.

To undertake such independent investigations and tests of materials, methods, and appliances as may be considered advisable.

The Committee's Reports on Tests with Materials, Methods of Construction, or Appliances are intended solely to state bare facts and occurrences, with tables, diagrams, or illustrations, and they are on no account to be read as expressions of opinion, criticism, or comparisons.

The Committee is not responsible for the views of individual authors as expressed in Papers or Notes, but only for such observations as are formally issued on behalf of the Executive.

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8 WATERLOO PLACE, PALL MALL, LONDON, S.W. 1.

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NOTE.

THOSE generally in charge of works and property cannot be expected to have either the necessary experience or knowledge that will enable them to advantageously direct their staff to deal efficiently with an outbreak of fire, especially if materials such as chemicals that require special handling are at risk. The same disadvantages apply to their deputies, works foremen, etc.

Where works or estates have their own private fire brigades, the experience gained at actual fires by these brigades is generally so limited that their superintendents or staff rarely know how to deal with exceptional hazards, and the same applies to the majority of country fire brigades who courageously endeavour to extinguish a fire, although they are often handicapped by lack of experience, and at the same time occasionally run the gravest risks by attempting to deal with a fire in an unsuitable manner both as regards method and means used.

It is only among the experienced professional firemen and the chiefs of large retained fire brigades who have had long experience of fires or have studied these problems that the correct way of handling fires might be expected as a matter of course.

With the rapid increase of works and establishments arising out of the War, in many of which fire questions are either neglected or dealt with by men lacking experience and knowledge, innumerable inquiries reach this Committee as to the best method of dealing with various classes of fire, the questions largely relating to material of a chemical nature, the storage of certain goods such as coal, timber, and forage, or difficult fires as those in roofs and hearths in old buildings temporarily adapted for war purposes.

To meet these numerous queries a number of practical hints have been set out by Mr. Sidney G. Gamble, F.S.I., A.M.Inst.C.E., who has had a lifelong experience of fires of every description, and who was for twenty-six years (1892 to 1918) Second in Command of the London Fire Brigade. At the special desire of the Committee Mr. D. W. Wood, whose knowledge of industrial fire hazards and dangerous trades is so extensive, has collaborated, contributing much valuable information and arranging the "Red Book" in the form in which it is presented.

Sections of the proofs have had the advantage of being seen by Major A. McN. C. Cooper-Key, C.B., Dr. C. H. Lees, F.R.S., and Lt.-Col. C. E. Phipps, C.B.

The Committee trust that this "Red Book" may be of service in a large field, and above all prevent the repetition of errors whereby fires have been allowed to extend when their spread could have been readily prevented if they had been dealt with in a more suitable manner.

ISSUED BY ORDER OF THE EXECUTIVE.

Offices of
The British Fire Prevention Committee,
8 *Waterloo Place, Pall Mall,*
London, S.W. 1, 1918.

FOREWORD.

THE following pages have been written with the object of placing in a concise and handy form some recommendations as to the best methods of extinguishing fires. No reference has been made as to how the various duties arising at a fire should be allocated amongst those dealing with it, nor to the most suitable way of manipulating the appliances at hand.

It may be said that no two fires are alike when all the circumstances are considered, and therefore it is impossible to dogmatize on the correct way to deal with fires.

Fire *Prevention*, which is more important than Fire Extinction, in that *prevention* is better than cure, is not dealt with as such except where it is necessary to make the context more explicit. At the same time if every fire-preventive precaution has been taken, accidents will occur, and it is advisable to know how to meet such contingencies.

Nearly all fires are due to carelessness in some form or other, and although this may seem a strong statement to make, yet nevertheless much as it is to be regretted, it is the case.

In preparing this "Red Book" the standard writings on the subject have been consulted, and the Author has repeated certain of his recommendations in the same language as in his contribution to a book entitled *Manual for the Use of Fire Brigades*.

The book has been divided into two parts: Part I deals with Fires and Fire Extinction generally, and Part II, arranged alphabetically, deals with fires in specified materials and premises, and in addition gives some explanatory notes on the physical and chemical terms frequently employed in this connection, and the names of a number of chemicals of a poisonous and/or corrosive nature in order that the necessary care may be taken when such materials are involved in a fire.

Any suggestions or criticisms will be gladly welcomed and careful attention will be paid thereto, in order that subsequent editions of this "Red Book" may be rendered more complete and its usefulness thereby extended.

SIDNEY G. GAMBLE.

16 *Queen Anne's Gardens,*
Bedford Park,
London, W. 4, 1918.

PART I.

INTRODUCTION.

Fires and Fire Extinction.

THE danger existing in every fire—however small—is the generation of heat and gas.

A fire that has been smouldering for some time will cause such a gradual rise in the temperature of the atmosphere and the materials within the building or compartment where the fire has occurred, that the breaking of a pane of glass will be sufficient to admit the necessary Oxygen to transform the heated air into a combustible and explosive gas that will be the means of communicating the fire to every part of the building.

"When a fire has been in progress for some time and there is a considerable mass of incandescent carbonaceous matter at the seat of the mischief, a large proportion of the product of incomplete combustion, *carbon monoxide*, begins to make its appearance with the smoke, steam, and carbon dioxide. This introduces a new and serious source of danger owing to the intensely poisonous nature of the gas.

"The increase in quantity of this gas with increase in the mass of burning material is chiefly due to the following factors :—

"1. When the mass of incandescent matter is large the amount of air is rarely sufficient to complete the combustion, and carbon monoxide is produced.

"2. With the increase of temperature the proportion of carbon monoxide to carbon dioxide increases with great rapidity.

"The playing of water on to the incandescent carbonaceous mass and the action of the steam which is thus generated on the glowing carbon yield carbon monoxide, which has a distinct toxic action."—LEWES.

It is of the utmost importance to locate the exact position of a fire at the earliest possible moment, and to deal with the adjacent property so as to prevent its taking fire.

As soon as the means of extinction (water, etc.) are ready at hand for instant use, openings should be made at the highest part of the building to allow the heated gases to escape. See that the water used is directed at as close a range as possible to the actual seat of the fire. It is, however, necessary to emphasize the fact that a stream of water will scarcely penetrate walls or roofs, and a good jet of water that may have satisfactorily dealt with the fire will become ineffective if interrupted in its course. Such interruption may be caused by the action of the wind or even by paper that has partly dropped from the papered ceiling of a room in which there is a fire.

Members of fire brigades, especially private fire brigades, should strive to become acquainted with the ramifications of large works, so that in the event of a fire, especially in night time, they can more easily find their way about. Those who are attached to individual factories should endeavour to know the various buildings and their different exits, so that in the event of the exit from one room or portion of a building being inaccessible, due to a fire, escape can be made from another point. When obtaining this knowledge by periodical inspection opportunity should be taken to draw attention to any exits which have been obstructed by goods, etc., being placed in front thereof.

If possible a fireman should not enter a building alone. When entering any building in which there is any quantity of smoke a lifeline should always be used, one end being fastened outside and the other to the wearer's belt, and by this means the way back can be more readily tracked.

Action of Water on a Fire.

The action of water used in extinguishing fire is threefold : (*a*) by reducing the temperature, (*b*) preventing the oxygen in the air reaching the burning mass, (*c*) breaking up the mass of material by the force of the jet, thus separating the burning matter and allowing the water to come into contact with the heated materials.

Water is the best substance for cooling purposes on account of its enormously high specific and latent heats. A given weight of water possesses greater cooling power than the same weight of any other substance at the same temperature.

Frequently in large fires after the application of water the fire breaks out again owing to the fact that the burning material still remains at a temperature higher than the burning-point. Sufficient water must, therefore, be used to cool the burning objects not merely below combustion point but below the burning and flashing points as well.

Even in some fires where it is not advisable in the ordinary way to use water it can be used if it is delivered from a safe distance with sufficient *force* and in sufficient *volume* to knock out the flame and cool down the burning material.

STEAM can be used in some cases with considerable advantage because of its expansive power, whereby the oxygen in the air is driven away from the immediate vicinity that the fire dies out from lack of oxygen. High-pressure steam is even still more advantageous.

Gases as Fire Extinguishers.

CARBON DIOXIDE, SULPHUR DIOXIDE, and AMMONIA.—These have an advantage over steam in that they do not form explosive mixtures when used on certain fires, particularly in ships' holds, as steam sometimes does when it is resolved into its constituent gases, hydrogen and oxygen.

FIRE-EXTINGUISHING APPLIANCES.

Buckets of Water and Hand Pumps.

These appliances are, without doubt, the most simple and most reliable of any First-aid Fire Extinguishing apparatus. Over a large number of years considerably more than 30 per cent of the fires in the London County Council area were extinguished with buckets only. If hand pumps are used in addition practically every small fire can be successfully dealt with.

It is essential to see that the BUCKETS are kept in their place, and filled with water. Arrangements should be made for their inspection at least every week. Buckets should not be kept out of doors because of the possibility of the water freezing.

Buckets with rounded bottoms have a considerable advantage over the ordinary sort, as they cannot be used for general purposes, and are, therefore, much more likely to be in their proper place. A large mug or cup can often be well used for throwing water on to the seat of a fire from a bucket.

HAND PUMPS require only a little attention, but should be overhauled every twelve months. They should be supplied with a stirrup or other fitting for use with the foot, so that one person can hold and direct the nozzle with one hand and pump with the other.

Hand pumps fitted in pails and corridor hand pumps on wheels for large establishments are useful ; particularly the latter if the nearest outside help is at some distance.

CALCIUM CHLORIDE added to the water (22·5 per cent by weight) materially improves its extinguishing properties, whilst it reduces the freezing point from 32° F. to 40° F.

Chemical Fire Extinguishers.

Reference is made in several places to Chemical Fire Extinguishers. These first-aid fire appliances generally operate on the following principle :—

The tank of the appliance is filled with water, usually containing Bicarbonate of Soda, and in addition a bottle containing acid (mostly Sulphuric Acid). Upon the acid being liberated into the water, either by breaking the bottle or turning it upside down, the action of the acid on the alkali evolves Carbonic Acid Gas at a considerable pressure sufficient to eject the water from the tank or container through the nozzle with some force.

A standard extinguisher of 2 gallon capacity would deliver a jet at about 50 lb. pressure some 20 or 30 feet for about $1\frac{1}{2}$ to $2\frac{1}{2}$ minutes. The usual charge for a 2 gallon appliance is 1 lb. of Bicarbonate of Soda dissolved in warm water and 4 oz. (avdp.) of Sulphuric Acid (S.G. 1·84).

Care should be taken when obtaining these appliances to see that they conform to the Specification of the Board of Trade (Marine Department), as otherwise there is a serious possibility of the apparatus bursting when used. Those made merely to comply with the Specification of certain Insurance Companies do not conform to the Board of Trade requirements in several important respects. On the other hand, the specifications of H.M. Office of Works, the Metropolitan Police, and the British Fire Prevention Committee are practically identical with that of the Board of Trade, so that extinguishers complying with any of these three forms are acceptable.

If a Chemical Fire Extinguisher is not available siphons of soda water have been found to be of some service.

There are several extinguishers obtainable which produce a FOAM. When they are set in operation the foam has the effect of blanketing out a fire, and they can frequently be usefully and easily employed on petrol, spirit, and oil fires. They require a special type of nozzle to spread the foam.

Small extinguishers holding about a quart and operated either by a capsule of compressed carbonic acid gas or else by a double-acting pump and containing CARBON TETRACHLORIDE, are much used for small petrol and electric fires. The action of heat on the chemical generates a dense black smoke, which keeps out the air and so smothers the flame. The chemical is also a non-conductor of electricity. A grave disadvantage, however, is that when the carbon tetrachloride is subjected to heat chlorine gas may be evolved, and this may prove dangerous to life, particularly in confined spaces.

All extinguishers should be frequently and thoroughly examined to see that they are in good working order, and that they have not been tampered with.

HAND GRENADES, which are generally small glass bottles filled with water with a small amount of various chemicals in solution, cannot be looked upon with favour for several reasons, and should not be relied upon.

Hydrants and Hose.

HYDRANTS of many patterns and sizes are to be found, from the half-inch garden hose tap to the large high-pressure ground type. All hydrants should be so designed to give a full waterway when open, and of sufficient strength to withstand the internal water pressure.

Never be satisfied with a *pressure* test only ; the test for *volume* is the criterion of the working value of the hydrant.

3 in. hydrant mains in view of the public have been known to have only $\frac{3}{4}$ in. supplies underground, and a case occurred of a public building, which was plentifully supplied with shining gun-metal and red fire appliances, but they were never connected to the water-mains ; needless to say, when *the* fire did occur the result was very disastrous.

It is of the utmost importance that any valves fixed in the mains should be so designed that on turning the key there can be no possible doubt but that the seat of the valve has been properly raised and the position of any "back pressure" valves should be clearly indicated.

The HOSE and FITTINGS should be kept clean, but care taken that the hose is not damaged at the couplings (especially by cleaning) or allowed to rot by reason of leaking valves.

The Water Companies usually insist upon hydrants being properly tested. It is advisable to arrange that all couplings are interchangeable with those of the Public Brigade, or a sufficient number of adaptors provided if this cannot be obtained.

"A pressure of about 50 pounds per square inch with 200 feet of hose will barely throw 150 gallons of water per minute to a greater height than 40 feet. A pressure of about 40 pounds per square inch at the hydrant would only give about 20 pounds per square inch at the branch pipe, and this would throw a stream not more than 30 feet high. Such pressures consequently require to be augmented by a steam or motor fire engine. A pressure of about 40 pounds per square inch at the hydrant will deliver about 1,000 gallons per minute into a dam; this would supply a steam fire engine, which could use five jets, at the rate of 200 gallons per minute each, and the engine could probably throw the jets to a height of 120 feet.

"The size of the nozzles are generally as follows:—

Capacity of pump . . .	500 galls. per min.	350 galls. per min.	115 galls. per min.
One stream	$1\frac{1}{4}$ in.	$1\frac{1}{8}$ in.	$\frac{3}{4}$ in.
Two streams	each 1 in.	each $\frac{3}{4}$ in.	each $\frac{9}{16}$
Three ,, ...	,, $\frac{7}{8}$ in.	2 at $\frac{5}{8}$ in. 1 at $\frac{1}{2}$ in.	—
Four ,, ...	,, $\frac{3}{4}$ in.	each $\frac{1}{2}$ in.	—

MERRYWEATHER.

Automatic Sprinklers and Drenchers.

AUTOMATIC SPRINKLERS consist of a small valve, the seat of which is held in its place by solder, which fuses at a predetermined temperature. These valves, or "sprinkler heads", as they are generally termed, are fixed just below the ceilings to pipe lines of graduated size according to the number of heads fitted thereon. The water supplies to the installation should be thoroughly adequate. When the solder melts, due to the heat arising from a fire, the water which is under pressure in the pipes is liberated, and this is directed over the seat of the fire in a fine rain by means of a deflector or spreader attached to the sprinkler head. Sometimes "sprinkler heads" some little distance from the fire, and not those immediately over it, actuate, due to the heat being deflected by a current of air owing to an open window or ventilating shaft. Usually there is one head to each 100 square feet of floor space, but it is best to consult the Fire Insurance Companies, who have drawn up the only recognized rules, before installing these appliances. On the installation there is also an alarm bell, which operates on water flowing through the pipes.

When the fire has been extinguished, but not before it is certain that this is the case, the main valve controlling the water supply to the sprinkler installation should be shut off in order that excessive water damage may not accrue, and fresh heads should be immediately fitted in the place of those which have been fused, and the water supply again turned on.

DRENCHERS.—These are a kind of sprinkler, but not automatic, and are usually installed over roofs and windows on the outside of a building which is subjected to exposure from adjoining premises. The pipes supplying the water are generally connected to the water-mains and controlled by special valves which are opened when required. Sometimes perforated pipes are used—frequently in connection with the fire safety curtains in theatres.

Dry Extinguishing Media.

SAND is the most usual material, but unless it is well washed, or silver sand, it has a tendency to cake. It is also detrimental to machinery. Its purpose is to smother out the fire by excluding the oxygen of the air.

SAWDUST with bicarbonate of soda in the proportion one bushel (8 gallons) of sawdust to 10 pounds of bicarbonate of soda forms a very serviceable material for smothering fires, particularly petrol, spirit, and other oil fires, in that it has the advantage over sand of floating on the top of the burning liquid. (*See* Petrol, Part II.)

DRY POWDER EXTINGUISHERS have been condemned in a circular issued by the Home Secretary to the Police Forces on fires caused by air raids in the following terms: "No reliance can be placed upon such appliances for effectively controlling fires such as are likely to be caused by bombs, explosive or incendiary"; and the same remarks equally apply to ordinary fires.

Asbestos Cloths.

These are very useful for smothering out fires in which liquids are involved. A cloth can be easily thrown or drawn over the top of a vessel containing burning spirit, etc., and by excluding the oxygen in the air extinguish the fire.

The Incorporated Association of London Dyers and Cleaners extensively use these sheets for extinguishing spirit fires in dry cleaning houses.

Automatic Alarms.

There are several classes of this most useful kind of apparatus practically all depending upon the expansion of metal, liquid, or air due to the heat arising from a fire. The majority are arranged to make an electrical contact due to the expansion, and so ring an electric bell, thus giving an automatic and early indication of any fire occurring.

FIRES OF FREQUENT OCCURRENCE.

Most fires can be subdued or kept in check by buckets of water, hand pumps, or extinguishers if the fires are discovered in time ; even a few buckets of water or a siphon of soda water may have the desired effect. A household mop or rug can also be used. Fires often look a great deal worse than they are, and no one should flinch from attacking a fire at close quarters, especially when it is in its earliest stages.

If there is much smoke it will be found that the air is clearer nearer the ground, therefore a stooping or even crawling attitude should be adopted and a wet cloth, etc., held or tied over the nose and mouth.

If the fire has made such headway that the inmates are compelled to clear out, all doors and windows should be closed, and they should be kept closed until the fire-fighting appliances are ready to be brought into use.

Curtains, blinds, etc., that have been fired by being blown from an open window into a gas bracket, or the drapings and other inflammable fittings of a wooden mantel-shelf that have been ignited by the radiated heat from a fire, can often be pulled down and smothered upon the floor by a rug or mat.

Should a lighted paraffin stove or lamp be knocked over, the flames could be extinguished by a rug or mat if it is sufficiently pressed down to exclude the air, or sand or the soil from flower-pots could be used to absorb the oil, thus excluding the oxygen of the air and reducing the temperature of the mass to a point below the ignition temperature, and so extinguish the fire.

Care should be taken to properly search round the neighbourhood of fires to see if any burning material has been blown into well-holes, lighting or ventilating areas, gutters, or other unfrequented places, and if so steps should be taken at once to extinguish it. There is often an accumulation of dried leaves and grasses in gutters, or upon the roofs of buildings, and a spark may fire this rubbish, and in turn melt the lead flashings, allowing the flames to ignite any felt or boarding attached to the roof timbers.

Roof Fires. (*See also* Churches, Part II.)

When dealing with outbreaks of fire in roofs, etc., it will probably be advisable to remove the roof coverings, etc. In such cases it should be borne in mind how they were originally erected, and removal should be carried out in the opposite way. Thus slates and tiles should be pushed upwards or pulled from above. They will then easily be removed from their nails, whilst in the case of lead and zinc it is best to unfasten the rolls, then the covering can easily be pulled up. In the case of galvanized or corrugated iron the heads of the bolts should be cut off, when the sheets would be easily removed. It should be noticed that in dealing with fires under galvanized iron each sheet must be removed and washed on both sides with water from the hose, or the heat remaining in the iron may start a fire if the iron comes in contact with readily inflammable material.

Hearth Fires.

In old buildings where timber was the principal fuel the flues were of necessity much larger in area, with the result that the smoke and gases from the fires were comparatively cool. Since the introduction of the fire grate with the raised hobs, and the Chimney Regulation Act requiring flues to be not less than 14 inches by 9 inches (this being the smallest size that a boy chimney sweep was able to climb), flues have been constructed of this size with the consequent increase in the temperature of the smoke, etc. This type of grate in turn has given place to the pattern with the hearth nearly level with the floor. When these have been fixed without the whole of the flooring and ceiling below being reconstructed in non-combustible material, numerous fires have occurred through the timbers supporting the hearth being set alight.

"MORTAR practically consists of a mixture of slaked lime and sharp sand, and when brickwork has been laid with this the first hardening of the mortar is dependent upon the slaked lime absorbing carbon dioxide from the air, which converts it into carbonate and causes it to harden. After this has set the action of heat upon it is again to burn the calcium carbonate back to lime, so causing the crumbling down of the mortar, and should a joist have been built in close to the casing of the flue hot gases will find their way through the perished mortar to it, and gradually bring about slight carbonization of the wood and occasionally cause its ignition."—LEWES.

Fires in Converted or Adapted Buildings.

Premises consisting of what was originally a number of separate houses or shops, and which have been joined up by removing portions of the party walls, most of the staircases, and often much of the lower part of the chimney-stacks, are very bad fire risks. In these cases the upper storeys are often left practically resting upon a few unprotected iron columns. A fire if not stopped at once is almost sure to gut the entire block, and cause the collapse of the larger portion of the buildings.

When fighting a fire in a building of this kind the hose and branches should be placed in positions where falling brickwork could be avoided. This type of building is especially dangerous, as there is usually a large amount of wood lining to the walls and ceilings, and during "sales" and at Christmas time a considerable quantity of flimsy material is suspended for show.

FIRES ON THE PERSON.

In the event of anybody being on fire, throw the person on the floor, and roll in a blanket, rug, coat, or other woollen material to smother the flames. When approaching such a person it is as well to hold the blanket, etc., in front of oneself to keep the flames away.

In the case of females it is of the utmost importance to ascertain if any part of their underclothing is on fire, as fatalities have arisen through the garments, often of flannelette, continuing to smoulder after the rescuers have thought the fire extinguished, and the injured person was in such a state of collapse as to be unable to explain the trouble.

PARAFFIN NO. 7 OR "BURNOL".—This is a new preparation recognized by the Navy and the Army as the best treatment for people suffering from burns, and it has been extensively used both by the English and French Authorities in the present War, with great success, even in the most serious cases. The British Fire Prevention Committee have arranged for the making up of the preparation under their supervision in tablet form, and in order that the users may feel satisfied that there is no risk of inferior paraffin wax improperly prepared being retailed to them when they ask for Paraffin No. 7, this particular preparation as supervised has been given the name of "Burnol". This name has also been given to certain sprayers and other accessories which facilitate this modern treatment of burns.

ACTS OF PARLIAMENT.

An Appendix has been added giving a list of the different Acts of Parliament, which indicate what rights owners of property have in the way of demanding efficient water supplies for extinguishing fires, the power conferred on local authorities to obtain suitable fire-extinguishing equipment, and various matters appertaining to Fires and Fire Brigades.

The legal position of Fire Brigades is, as will be seen if these Acts are carefully studied, very complex and not satisfactory, and this is much to be regretted.

PART II.

NOTE.—*Many compounds of the chemicals mentioned in the following pages are as dangerous as, and in some cases even more dangerous than, the chemicals themselves, but to specify all the compounds would have made this "Red Book" too voluminous for ready reference.*

Acetate of Lead (Sugar of Lead).

Poisonous.

Acetic Acid. (*See* Acids.)

Acetone. (*See* Ether.)

Acetyl-cellulose. (*See* Cellulose.)

Acetylene Gas. (*See* Carbide of Calcium.)

This is a dangerous gas, as the explosive range is so wide (*see* Appendix, Table II), and as its density so nearly approximates that of air (*see* Table I) it is not readily dispersed, and therefore if allowed to escape it is nearly always in a condition conducive to cause a severe explosion.

Acids.

The fumes from acids are dense and heavy, and consequently a stooping attitude should not be adopted in dealing with a fire in which acids are involved.

ACETIC ACID boils at 244° F., giving off inflammable vapours. Poisonous and corrosive.

CARBOLIC ACID or PHENOL.—Poisonous and corrosive.

FLUORIC ACID.—Poisonous and corrosive.

HYDROCHLORIC ACID or MURIATIC ACID.—Corrosive.

HYDROCYANIC ACID or PRUSSIC ACID.—Poisonous and inflammable.

NITRIC ACID should be diluted with a *large* quantity of water to render it comparatively harmless. (A small quantity of water is dangerous.)

Dangerous fumes are given off by this and other acids, and great care should be taken to avoid inhaling them. The effects of such fumes are frequently not noticed for some time afterwards—even twenty-four hours may have elapsed—consequently men who have been in contact with these fumes should inhale weak ammonia, ether, or alcohol, and drink milk or cream, and at once call for medical advice.

OXALIC ACID.—Poisonous and corrosive.

SULPHURIC ACID does not evolve such dangerous fumes to the human system, and water may be used on a fire where this acid is involved, but it must be in large quantity, otherwise the heat generated would cause steam to rise, which would absorb the acid and so give off fumes.

Acids and Alkalis.

ACIDS	ALKALIS
(1) Turn blue litmus-paper red.	(1) Turn red litmus-paper blue.
(2) Have a sharp sour taste.	(2) Have a soapy taste and touch.
(3) Set free carbon dioxide from carbonates	(3) Absorb carbon dioxide and form carbonates.

It will be seen from this that acids have exactly opposite properties to alkalis.

Action of Water on a Fire. (*See* Introduction, p. 8.)

Aeroplane Varnish. (*See* Dope.)

Agricultural Fires. (*See* Hops, Spontaneous Combustion.)

Where a stack is found to be alight in close proximity to other stacks it is well that steps should at once be taken to clear the ground between the stacks of all straw or other inflammable material, and to protect the lower edges of the unfired stacks with doors or similar articles to shield the lower portion of those not on fire, whilst the tops and sides should be protected in some manner from any embers being blown thereon from the fire. This can be done by covering the unburnt stacks with old blankets, tarpaulins, mats, rugs, or rick cloths of any kind. Any water that can be obtained should be conveyed to the ridges of the various unburnt stacks and poured down on the covering materials so as to thoroughly damp them. Provided there is only a moderate wind, it may be possible by the above-mentioned procedure to isolate the burning stack, and by carefully watching save the adjoining stacks.

On the arrival of fire-extinguishing appliances the above suggested course of covering up the untouched stacks should be continued until a sufficient supply of water is at hand. When this is ready and with plenty of help the burning material may then be damped down, and the stack cut up ; the portions can then with advantage be carted into open fields and tipped into small heaps.

Many ricks are stacked well clear of the ground. If these are alight underneath the whole must be removed, but if they are stacked on the ground without any intervening material the central portion may be saved by cooling down the outside and cutting off the smouldering outer portion.

All stacks are liable to be fired from the outside, but stacks of hay, seeds, etc., are also particularly liable to destruction through overheating when they have been stacked before the grass is dry, which causes spontaneous ignition near the centre of the stack. It is seldom, if ever, that any salvage is obtained from a stack that has got thoroughly alight. If the stack is sufficiently distant from any buildings or other property it is not worth the expense and trouble of extinction, and might be left to burn itself out, even if this occupies, as sometimes happens, a period of three weeks.

It must be remembered that straw stacks invariably burn from the outside towards the centre, not being liable to spontaneous combustion.

To remove stacks, even when fired, it is necessary to unload them in the reverse way to which they have been built. Working from the top about 24 inches at a time will be found the easiest way. If the men cannot carry on the work with forks, an old steel wire rope which has been used for steam-ploughing tackle is useful. This should be placed about 24 inches down from the top round the rick, and by keeping it in a level position with the aid of two or three firemen with steel prongs the stack can be pulled apart by horses or men.

An ample supply of water should be at hand to damp down at once any fire whilst the straw or hay is being removed to a safe distance from other ricks or buildings.

GROWING CROPS, UNDERWOOD, also FOREST and HEATH, when on fire can, if sufficient assistance is at hand, be beaten out with sticks, or a gap made sufficiently wide by cutting, or, if this cannot be done in time, firing a belt in front of the fire and extinguishing the same before the main fire reaches the spot. This gap should in no case be less in width than twenty times the height of the burning crop, etc.

Alcohol. (*See* Ether.)

Is highly inflammable, but when mixed with water its inflammability is reduced.

PROOF SPIRIT is an old method of indicating the standard strength for alcohol. Its density is 0·91984 at 60° F., and this contains 49·24 per cent of alcohol by weight.

Alkalis (Caustic). (*See* Lime.)

Aluminium. (*See* Metals and Minerals.)

Ammonia.

No risk of fire, the danger being purely one of explosion. It is, of course, dangerous to life. Some compounds of Ammonia are particularly explosive. Must not be allowed to mix with Bromine.

Ammonium Nitrate. (*See* Explosives.)

Ammonium nitrate is an oxidizing agent liable to form an explosive with any combustible substance.

Ammunition (Small Arms). (*See* Gunpowder, Explosives, and Munition Factories.)

Amyl-acetate. (*See* Ether.)

A highly inflammable liquid. Used as a solvent for many things and for flavouring smells like "pear-drops".

Animals.

Most animals take great fright at any kind of fire or light, and it is most difficult to remove them from their stables. It has been found that the best method to adopt is for their own attendants (if possible) to go quietly into the buildings, harness them, cover up their eyes, and lead them out. If this cannot be done throw a coat or cloth over their heads and quietly lead them, always remembering that any agitation upon the part of the person undertaking this duty is at once conveyed to the animals.

In cases of fire at a zoological collection or circus in which wild animals are kept, the attendants should in all cases be consulted and the cages covered up in order that the light and smoke may not penetrate.

Aqua Fortis. Nitric acid. (*See* Acids.)

Aqua Regia. (*See* Acids.)

A mixture of one part nitric acid and three parts hydrochloric acid.

Barges. (*See* Ships.)

Barium. (*See* Metals and Minerals.)

Rapidly oxidizes in air and decomposes water. Nearly all its compounds require careful handling.

Benzene, Benzine, Benzol. (*See* Ether.)

Bismuth. (*See* Metals and Minerals.)

Bisulphide of Carbon. (*See* Carbon Bisulphide.)

Black Powder.

Another name for gunpowder, q.v.

Bleaching Liquids and Powders (Chloride of Lime).

Corrosive.

Blinds. (*See* Fires of frequent occurrence, in Part I.)

Boiler Explosion.

When a boiler, even a small one, explodes it may damage a vital part of the structure of the building in which it is located. Before any timber or brickwork in the building which is damaged is removed an architect or building expert should be consulted.

Careful investigation should be made to see if any firebrands have been projected from the furnace of the boiler by the explosion, as if they are not extinguished they may set some adjacent property on fire. The Board of Trade should be informed of any boiler explosion within twenty-four hours.

Boiling Points. (*See* Appendix A, Table V.)

The boiling point of a liquid is of considerable importance ; the lower the temperature at which the liquid boils the greater the danger. As the liquid boils it expands and sufficient pressure may be generated to burst the container, and if the liquid is of an inflammable character fire may thus be spread about in all directions.

If the pressure be increased the temperature of the boiling point is raised, and so in this way high-pressure steam may cause fires. At ordinary atmospheric pressure (15 pounds per square inch) water boils at 100° C. (212° F.), but the following table gives the approximate temperature for different pressures :—

30 lb. . . .	249° F.
75 lb. . . .	306° F.
100 lb. . . .	327° F.
200 lb. . . .	381° F.
300 lb. . . .	417° F.
400 lb. . . .	449° F.

Breweries. (*See* Dust Explosions (Malt Mills), Hops.)

Brimstone.

Another name for Sulphur, q.v.

British Thermal Unit or **B. Th. U.** (*See* Heat.)

Bromine.

Poisonous and corrosive. Must not be allowed to mix with ammonia.

Bronze Powders. (*See* Metals and Minerals.)

Calcium. (*See* Lime.)

Burns in air to form the oxide CaO (quicklime), and rapidly combines with water forming $Ca(OH)_2$ (slaked lime).

Calcium Phosphide.

Decomposed by water, forming spontaneously inflammable phosphoretted hydrogen, which burns with a white light. Used for signal lights at sea.

Calorie. (*See* Heat.)

Camphor.

Boils at 400° F., giving off very inflammable vapour.

Carbide.

This term is generally used when referring to calcium carbide, but when carbon combines with metals and substances of a metallic character the compounds are usually termed carbides, such as calcium carbide, potassium carbide, etc. Practically every carbide generates an inflammable gas when it is brought into contact with water.

Carbide of Calcium. (*See* Metals and Minerals.)

Carbolic Acid. (*See* Acids.)

Carbon. (*See* Metals and Minerals.)

Carbon Bi- or Disulphide. (*See* Ether.)

When kept in large quantities it is generally stored under water, as it is considerably heavier than water.

Carbon Dioxide (CO_2). (*See* Introduction, page 7.)

Often referred to as Carbonic Acid Gas. Most useful in extinguishing fires, as it is a non-supporter of combustion. Over 12 per cent in air is said to be dangerous to life, and 15 per cent will extinguish lights.

Carbon Monoxide (CO). (*See* Introduction, page 7.)

Not to be confused with Carbon Dioxide. A most poisonous and highly inflammable gas, as well as readily forming explosive mixtures with air.

Carbon Tetrachloride. (*See* Chemical Fire Extinguishers and Petrol.)

Carbonaceous Dusts. (*See* Dust Explosions.)

Cartridges. (*See* Gunpowder.)

Cattle. (*See* Animals.)

Caustic Alkalis. (*See* Lime.)

Caustic Soda. (*See* Sodium Hydrate.)

Celluloid. (*See* Cinematograph Films.)

Celluloid is a nitrated cellulose, and the only difference between gun-cotton and celluloid is that the nitration has not been carried so far in the manufacture of celluloid as in that of gun-cotton.

Ignites at about 300° F. without the application of a flame.

Celluloid articles when burning evolve large quantities of poisonous gases, and are only extinguished by complete cooling ; if possible it is better to protect the surroundings, leaving the articles to burn out ; this they will do in a few minutes.

Water, if applied, must be used in large quantities, and thrown on the fire with great force.

Cellulose.

Cellulose, speaking broadly, is the non-nitrogenous framework of the individual cells of vegetable organisms. Can be readily "nitrated" by the action of nitric acid, and then forms the basis of many explosives and celluloid. When it is treated with acetic acid it forms an acetyl-cellulose, which is not so inflammable.

Cement (Portland). (*See* Dust Explosions.)

Coal grinding is now frequently performed at these works, with the consequent evolution of dust.

Cements.

Cements for celluloid and many other articles contain highly inflammable liquids.

Charcoal.

May burst afresh into flame after having been on fire, although it has been drenched with water.

Chemical Works.

Fires in chemical works and premises in which large quantities of chemicals are stored require the greatest care on the part of the firemen, and in every case it is best to *see* and take the advice of the manager or man in charge of the premises. The large number of chemicals stored, both of an acid or alkali nature, are so dangerous that it is of the utmost importance to know the position of the stock before entering a building where there is reason to suppose that the fire has been caused by acids. A stooping position to avoid the smoke must not be adopted, as the fumes of most acids are dense and heavy.

Chimneys. (*See* Hearth Fires in Part I.)

FOUL FLUES.—Make sure you are dealing with the flue on fire.

Throw salt or sulphur on the fire in the grate to exhaust the oxygen in the flue, and in any case close up tightly the bottom with damp sacking, carpets, etc.

Water must be used to wash the soot from the ledges at the bends, and to extinguish any timber that has been built into the brick-work and which may be burning.

Chemical extinguishers can be usefully applied in some cases. Great care should be taken to ascertain that all combustible matter is removed from the flue and hearth before leaving the building.

Chlorate of Potash. (*See* Explosives.)

Is an oxygen carrier, and as such is much used in the manufacture of explosives and in dye works. It is also used in some pharmaceutical drugs. When mixed with organic substances it explodes with great violence, especially if it is being ground, pounded, or warmed.

Chloride of Lime (Bleaching Powder.)

Corrosive.

Chloroform. (*See* Ether.)

Churches. (*See* Roof Fires in Part I, and Wood.)

Fires in churches usually commence at or near the heating apparatus or the organ, and should the fire obtain a hold of the roof the only way of preventing its extension over the whole building is by stripping the lead or tiles and cutting a space completely through the roof covering some distance in front of the fire and forming a gap sufficiently wide to allow time for water to be thrown upon the burning parts, otherwise the felt sarking or lining which is used between the covering and the boarding is sure to smoulder and allow the fire to work its way along until the whole roof structure is destroyed.

Cinematograph Films.

Cinematograph films are made of celluloid. If a film gets on fire, and will not do damage to other property, it is best to allow the film to burn out rather than to try to extinguish it with water, as unless a very large quantity of water is applied it cannot be quenched, and the action of the water only causes a very dense gas to be evolved.

Under the Cinematograph Act damp blankets must be provided in the operating chamber for use in the event of a fire.

If on fire in a vault or confined space where no fresh air can get to the burning film different gases are evolved to those when burning in the open, and they have explosive properties. Therefore all vaults should be thoroughly ventilated.

The films used in toy machines are of a specially inflammable and dangerous character.

The storage of films is regulated under the Defence of the Realm Regulations.

Circus. (*See* Animals.)

Coal.

Fires in coal wharves and other stores are usually caused by spontaneous ignition—wet or very small soft or impure coal is very apt to fire in this way—or through being stacked near steam pipes or hot air flues.

The best way to extinguish a fire in a COAL or COKE stack is to remove sufficient of the bulk by digging trenches about 2 feet wide and 2 feet deep in the stack around the heated area to allow the heat to escape, only using just sufficient water to bring down the temperature of the coal below the point of ignition if the trench digging on several successive days has not been sufficient. This procedure assumes that the fire has been discovered in its earliest stages.

Cobalt. (*See* Metals and Minerals.)

Coefficient of Linear Expansion. (*See* Gases.)

The ratio of the increase in length produced by a rise of temperature of 1° C. to the original length.

The difference between the Coefficient of Expansion of various substances used in buildings when subjected to heat causes great strains in a structure and is sometimes the reason of a building collapsing.

Mean coefficients of linear expansion for 1° between 0° and 100° C. :—

Pine	0·000,006,080	Copper	0·000,017,182
Marble	0·000,008,490	Brass	0·000,018,782
White glass	0·000,008,613	Tin	0·000,021,730
Cast iron	0·000,011,250	Aluminium	0·000,023,130
Sandstone	0·000,011,740	Lead	0·000,028,575
Wrought iron	0·000.012,204	Zinc	0·000·029,417

Another authority gives the following table :—

EXPANSION BY HEAT IN DEGREES FAHR.

	1 degree. 1 part in.		1 degree. 1 part in.
Fire-brick	365,220	Steel	151,200
Granite	187,560 to 228,060	Iron-rolled	149.940
Glass (Crown)	211,500	Sandstone	103.320
Marble, granular white dry	173,000	Brass	97,740
Cast iron	162,000	Lead	62,180
Slate	173,000	Zinc	61,920
		White pine	440 530

Collieries. (*See* Mines.)

Collodion. (*See* Ether.)

Collodion Cotton.

A species of gun-cotton, but with a smaller nitrogen content.

Colours corresponding to Temperature. (*See* Appendix A, Table IV.)

Confectioners (Manufacturing). (*See* Dust Explosions.)

Cordite. (*See* Explosives.)

An explosive of the smokeless type.

Cotton.

On account of the hollow structure of the fibre, cotton is more inflammable than practically any other fibre.

Cotton, Hemp, Jute, and other Vegetable Fibres.

Fires in cotton, hemp, jute, and other vegetable fibres are mostly met with at seaports. Unless the steel bands round the bales have been broken, fire cannot readily get beyond the surface of those that have been hydraulically pressed. The flames will, however, quickly run over the outside and burn the looser portions, which, giving off a dense smoke, often render the original seat of the fire difficult to approach until an opening has been made in the roof of the building to allow the smoke to escape. In these cases the whole surface of the goods must be wetted and the bales turned over. In the case of bales that have not been so pressed the damage will in all probability be considerably more.

The salvage from jute fires when dumped down in open spaces is so susceptible to combustion that it will fire by the least spark, or even the sun's rays when completely dry.

Cotton Mills. (*See* Factory Buildings.)

Cresylic Acid.

Poisonous.

Cyanides.

Cyanides of copper, potassium, and sodium are poisonous.

Density. (*See* Specific Gravity.)

Desiccation.

The process of drying.

Detonators. (*See* Explosives.)

Diffusion of Gases. (*See* Gases.)

Distilleries. (*See* Ether and Petrol.)

Dope.

Dope or Aeroplane Varnish is highly inflammable until the solvents have evaporated.

Dry Cleaning. (*See* Ether, Petrol, and Spontaneous Combustion.)

Dust Explosions.

In an explosive gaseous mixture there is air, and some combustible gas, say hydrogen, intimately mixed. Suppose, instead of hydrogen, is substituted a combustible solid substance in a minutely fine state of division, a very similar condition results. This is what obtains when the dust of a combustible material is suspended in air. And so may be explained the danger of explosion in FLOUR, MALT, and SUGAR MILLS, SEED-CLEANING, and all other operations which may involve the production of DUST OF A CARBONACEOUS NATURE.

Dye Works.

Many of the SYNTHETIC DYES are composed of chemicals also used in the manufacture of modern explosives, and consequently the same care should be taken in dealing with a fire in which these dyes are used, and particularly in those premises where they are made, as in an explosive factory. As an example picric acid is used for dyeing fabrics a yellow colour.

Elastic Web Works. (*See* Factory Buildings.)

Electrical Fires.

Cut "dead" the installation at the main switch, unless the current is required for lighting a large area, and in addition to allow the inmates to find their way out and the firemen to carry on their their work. If it is not considered advisable entirely to switch off all the current, sections of the installation may be cut out by removing local fuses.

Live wires hanging in dark rooms are troublesome, especially to men wearing metal helmets, whose clothing and boots are wet, and which therefore become good conductors. These wires may be cut with a fireman's axe if the handle is dry, and grasped with rubber or dry cloth, and probably only a slight shock will be experienced.

On no account should water or the contents of chemical extinguishers charged with water be used near electrical wires or appliances until the current has been switched off. The same applies to damp earth and sand ; the carbon in damp coke breeze or cinders might cause the fire to increase.

Dry ashes, earth, or sand may be used, and also the extinguishers containing carbon tetrachloride, as this chemical is a non-conductor of electricity ; but great care must be used in operating them, as their capacity is very limited. (As to Carbon Tetrachloride *see* pages 10 and 39.)

In power-houses, telephone exchanges, or other large installations no water should be used before consulting the responsible electrician in charge.

When there is a fire on electric mains in the streets dry sand or earth only should be used, until the officials of the supply arrive with their special appliances.

Endothermic. (*See* Exothermic.)

A term applied to a substance in the formation of which heat was *absorbed*. Endothermic substances are generally unstable and often explosive.

Engravers. (*See* Process Engravers.)

Essential Oils. (*See* Ether *and* Petrol.)

Ether. (*See* Petrol.)

Is extremely volatile and inflammable. Vapours when mixed with air are highly explosive. Ether will not mix with water.

Ether and similar fluids, such as ACETONE, BENZENE, CARBON BISULPHIDE, and CHLOROFORM, are extremely volatile and inflammable. Warehouses or shops containing even small quantities of these liquids require both during and after a fire great care upon the part of all employed upon the premises. If a bottle of ether which has been subjected to heat during a fire is broken it will fill a good-sized room with fumes that may restart a fire which was thought to have been extinguished, but in which some smouldering material remains.

Exothermic. (*See* Endothermic.)

A term applied to a substance in the formation of which heat was *evolved*. Consequently, to decompose an exothermic compound heat or energy is required, whilst in the decomposition of an endothermic substance heat is evolved. Most substances are exothermic.

Expansion (Coefficient of Linear). (*See* Coefficient of Linear Expansion.)

Explosions (Dust). (*See* Dust Explosions.)

Explosive Factories. (*See* Munition Factories.)

Explosive Range. (*See* Gases.)

Explosives. (*See* Gunpowder, Munition Factories, Nitro Compounds.)

"An explosive is a solid or liquid substance or mixture of substances which is liable on the application of heat or a blow to a small portion of the mass to be converted in a very short interval of time into other more stable substances largely or entirely gaseous.

"The temperature of the products is always very high in consequence of the liberation of a considerable amount of heat in the chemical changes that take place. . . .

"When an explosive such as 'SMOKELESS POWDER' is 'ignited' it burns from the surface inwards in parallel layers with a velocity which depends upon the pressure, but even under several thousand atmospheres never exceeds a few metres per second; the ignition is communicated from layer to layer by the heat generated. On the other hand, when an explosive is detonated the wave of detonation proceeds apparently through the mass of unaltered explosive with a velocity of several thousand metres per second changing the material as it proceeds. In this case the explosion is communicated by pressure, but possibly this pressure acts by suddenly raising the temperature by compression.

"When GUNPOWDER is ignited it burns very rapidly, even if unconfined. . . .

"For the ignition of POWDERS IN FIRE-ARMS heat only is required; for the detonation of HIGH EXPLOSIVES, on the other hand, a very sudden and instant blow is necessary, and this can only be obtained by means of an explosive which itself detonates with a velocity of several thousand metres per second.

"DETONATORS are always fired by means of heat supplied either by a burning fuse or by a priming ignited by an electric current.

"When a light is applied to a FULMINATE, at first it only burns with a velocity of about 10 metres per second, but the reaction becomes more and more rapid, and within an interval of time, which is probably not more than $\frac{1}{5000}$ of a second, detonation sets in."—MARSHALL.

As indicating some chemicals that have explosive tendencies, or may under certain conditions cause an explosion, it is interesting to note that in the United States of America, under "The Explosive Regulation Law" of October 6, 1917, a licence is necessary to manufacture, sell, or purchase any of the following "ingredients":—

Bichromates: Ammonium, Potassium, Sodium.
Chlorates: Barium, Potassium, Sodium, Strontium.
Chromates: Ammonium, Barium, Calcium, Lead, Potassium, Sodium.
Nitrates: Ammonium, Barium, Copper, Ferric, Lead, Magnesium, Nickel, Potassium, Silver, Strontium.
Nitric Acid: Aqua Fortis, Fuming. Nitric Acid of all grades and strengths, Mixed Acids.
Perchlorates: Perchlorio Acid, Potassium.
Perborates: Magnesium, Sodium, Zinc.
Permanganates: Calcium, Potassium, Sodium.
Peroxides: Barium, Calcium, Magnesium, Oxon (cubes and cartridges), Sodium, Strontium, Zinc.
Phosphorus.

Factory Buildings.

If a fire occurs in one of the older type of this class of building, or in one of those built with the maximum amount of window-space and with the minimum quantity of brick or other support, great care should be exercised. Many have unprotected iron joists, holes in the floor for belting, rope races, lifts and stairs, wooden partitions to protect the machinery and soft wood linings to the walls, and in addition, for ease in supervision, large open floor areas ; many of these buildings are also five and six stories in height. All these features tend to cause a fire to spread rapidly.

Those factories, used in the textile trades such as COTTON, ELASTIC WEB, FLAX, HEMP, JUTE, and WOOLLEN MILLS, are especially dangerous on account of the combustible nature of the material in process of manipulation, the high temperature of the rooms, and the large amount of organic dust floating through the factory.

On arrival it is often necessary to get a checking jet of water to work from the ground level until other lines of hose are brought into play up the staircases, this may occupy some time owing to blocks caused by the employees trying to rescue their clothing or goods improperly stored on these " means of escape in case of fire ".

Fats. (*See* Liquids.)

Fireworks.

Are usually formed by the charging of paper cases with gunpowder and other chemicals, and fitted with a quick match or touch-paper primers. A small spark is sufficient to set these primers alight, but as a rule with intervals of time, the force of the explosion however varies with the rigidity of the cases or the spaces allowed for the gases generated to expand.

Water will soon reduce the risk, and with the exception of the noxious fumes, which may contain a proportion of carbon monoxide or sulphuretted hydrogen, the danger from the continuous explosions of the cases is slight.

Flash Points. (*See* Appendix A, Table VI.)

Flax Mills. (*See* Factory Buildings.)

Flour Mills. (*See* Dust Explosions.)

Modern flour mills are constructed to grind the flour very fine, and in order that as small a quantity as possible of this fine flour may be lost the operation of milling is carried out in enclosed receptacles mostly formed of thin wood (pine or fir varnished). The corn, flour, and offal is transported from one machine to another, often considerable distances, by conveyors in wooden ducts.

The temperature of flour mills is usually considerably above the external air, and the whole building must of necessity be kept quite dry, therefore they are in a condition to burn rapidly should a fire occur.

Fires in flour mills are usually caused by friction of the machinery or by a small particle of flint or steel or iron in the grain sparking on contact with the stones or steel rollers.

Most flour mills are equipped with sprinkler installations, and some of the sprinkler-heads are fixed inside the ducts.

From the above it will be understood that a large amount of very fine organic matter is always present in flour mills ; this is a highly inflammable substance, and it has been known to flash from the source of the fire through ducts and fire a container 100 feet distant in another building, passing round bends and several sprinkler-heads without actuating them in its passage owing to the rapidity thereof.

Beyond the usual procedure at mill fires, firemen must not rest content until every avenue by which a spark may have travelled from the original fire has been traced. It is also well to remember, in order to save personal accidents, that floors and steps covered with flour become very slippery when wet, and so also do the underside of damp boots.

Fluoric Acid. (*See* Acids.)

Fluorine.

The most reactive element known. Unites with hydrogen with explosion. Most elements burn in it. Instantly decomposes glass.

Forests. (*See* Agricultural Fires.)

Foundries. (*See* Metals and Minerals.)

Fusel Oil. (*See* Ether.)

Highly inflammable liquid.

Gases.

Gases expand more than solids and liquids, but, whereas solids and liquids all expand differently, all gases expand very nearly alike. Charles found that all gases expand $\frac{1}{273}$ part of their volume at 0° C. for every increase in temperature of 1° C. The corresponding decimal fraction is 0·003665, so that one volume of air at 0° C. becomes 1·003665 volumes when heated 1° C. This fraction is called the COEFFICIENT OF EXPANSION of gases.

If gas is subjected to an increase of pressure, the volume of the gas becomes less, and when the pressure is withdrawn the gas immediately expands again and occupies, if the temperature remains constant, exactly the same volume which it did before the pressure was increased.

Solids and liquids can only be compressed to a very slight extent.

The law representing the relation between the volumes of a gas and the pressures to which it is subjected is termed Boyle's or Mariotte's Law, from the names of the discoverers, and it is as follows : The volume occupied by any gas is inversely proportional to the pressure to which it is subjected.

DENSITIES.—The weight of a gas is generally compared with either hydrogen or the atmosphere. As this book is dealing with the "fire" aspect, the densities of the various gases enumerated in Table I in Appendix A are compared with that of the air — therefore overhead ventilation and means of escape should be provided for those lighter than air and floor ventilation, etc., for those that are heavier.

DIFFUSION OF GASES.—The rate at which gases diffuse varies greatly. Experiments show that the velocity of diffusion is inversely proportional to the square roots of their densities; thus 4 volumes of hydrogen will diffuse through an opening in the same time as 1 volume of oxygen is able to do so, oxygen being sixteen times as heavy as hydrogen.

EXPLOSIVE RANGES.—Many gases when mixed with air in varying proportions have highly explosive properties. Table II in Appendix A gives the ranges of these proportions; thus carbon monoxide 16·6 to 74·8 per cent means that any mixture from 16·6 per cent of carbon monoxide and 83·4 per cent of air to 74·8 per cent of carbon monoxide and 25·4 per cent of air is explosive.

Gas Fires in Buildings.

If gas from a broken gas pipe is alight, turn off the gas on the Gas Company's side of the meter. Should the fire be in or close to the meter it may be necessary for a person, protected from the heat by a wet rag or blanket, to make a dash for the gas cock. Be careful not to displace the handle, as it is difficult to turn the cock with a spanner near intense heat.

Gas Fires in the Open.

Should the fire be caused by a broken main that is too large to be dealt with by plugging the broken main with soap and wood, it is best to allow it to burn until the Gas Company's men cut off the supply. This they usually do by inserting bladders some distance on each side of the fracture.

Great care is required in cutting off the gas in large mains that are alight. If when this is done the bladders are filled too quickly the gas pressure is so reduced as to allow an inrush of air from the open end and an explosive mixture may be formed, and the explosion may fracture the main on the works side of the bladder.

All adjoining property should be carefully protected until the mains are completely sealed. Remember that about 14 per cent of coal gas mixed with air forms the most explosive mixture. Any decrease or increase in the proportion of gas reduces the explosive action of the mixture proportionally until under 8 or over 19 per cent is safe. Some authorities give the proportions as 5 and 28 respectively.

Grease. (*See* Liquids.)

Growing Crops. (*See* Agricultural Fires.)

Gun-cotton. (*See* Explosives.)

Even when "wet" will explode under certain conditions.

Gunpowder. (*See* Explosives.)

Gunpowder is composed of the following :—

75 %	Saltpetre	KNO_3
10 %	Sulphur	S
15 %	Wood Charcoal	C

Gunpowder may be safely removed from the neighbourhood of a fire, provided no loose powder is allowed to fall out of the parcels and that they are protected from sparks. Men cannot work in a temperature of 500° F., which is required before gunpowder will ignite.

SMALL-ARMS AMMUNITION is to be met with in many retail shops, but unless confined in tight cases little danger need be anticipated from the repeated explosions which may occur.

Experiments have proved that large (elephant gun) cartridges will not communicate an explosion from one to another, but each cartridge causes a separate explosion and may be considered harmless and little personal risk may be expected from handling them. The explosion of a single cartridge, though harmless in itself, may explode any gunpowder near it with serious results, as it is legal to keep as much as 50 lb. in a special box on registered premises.

Hay. (*See* Agricultural Fires.)

Hearths. (*See* Fires of frequent occurrence, in Part I, and Chimneys.)

Heat.

Heat travels from one body to another by conduction, convection, or radiation. In CONDUCTION the particles pass on the heat from one to the other. In CONVECTION the hot particles move upwards from the stores of heat and cooler ones take their place. This is how liquids and gases chiefly get heated. RADIATION is due to the vibrations of a heated body being transmitted through the air, or through space, e.g. the heat of the sun transmitted through space to the earth.

Radiated heat is exemplified in the action of a fire setting alight goods in an adjoining building in which the communicating opening is only protected by an iron door, and which has become red hot due to a fire.

The terms "temperature" and "heat" must not be confused. TEMPERATURE may be defined as the intensity of heat.

In order to measure TEMPERATURE or degree of heat a THERMOMETER is employed, whilst QUANTITIES or amount of heat are measured by a CALORIMETER.

THERMOMETERS are graduated in different scales, the most used being FAHRENHEIT, with 32° for the freezing point of water and 212° for the boiling point, and CENTIGRADE, with 0° for the freezing point and 100° the boiling point.

To convert degrees Centigrade to Fahrenheit multiply by 9, divide by 5, and add 32 ; and to convert degrees Fahrenheit to Centigrade deduct 32 and multiply the result by 5 and divide by 9.

SPECIFIC HEAT.—The ratio of the quantity of heat required to raise the temperature of a given mass of any substance 1° C. to the quantity of heat required to raise the temperature of an equal mass of water 1° C. is called the specific heat of the substance.

CALORIE.—The amount of heat required to raise 1 gramme of water through 1° C. This is generally indicated by a small "c", whilst a capital "C" is used for the amount of heat required to raise 1 kilogramme of water through 1° C.

BRITISH THERMAL UNIT.—That quantity of heat required to raise 1 pound of water through 1° F. at or near 30·1° F.

1 B. Th. U. = 0·251996 C. or 252 c.

LATENT HEAT.—Latent heat is the stored or hidden heat, which is either taken up or given out during a physical change of state, the substance remaining at the same temperature until the change is completed.

The LATENT HEAT OF A LIQUID is the number of calories of heat required to change 1 gramme of the solid at the melting point to liquid at the same temperature.

The LATENT HEAT OF A VAPOUR is the number of calories required to change 1 gramme of the liquid at the boiling point to vapour at the same temperature.

The LATENT HEAT OF STEAM is 536. A volume of steam is about 1,728 the times the volume of the water from which it is formed.

Heaths. (*See* Agricultural Fires.)

Heating Apparatus. (*See* Churches, Boiling Point, and Wood.)

Hemp Mills. (*See* Factory Buildings.)

Hops.

Hops when drying in kilns are loose, and when dry burn so quickly that the surroundings should be well protected before any attempt is made to subdue the fire. Hops when dry are stored in pockets made of sacking 6 feet in height and from 26 to 34 inches in diameter, and so tightly packed and hard that they are not easily fired, but they will absorb enormous quantities of water, even to eight times their weight, without bursting the coverings, in contradistinction to rags, etc., which burst their containers. The greatest care should be taken to use the minimum quantity of water, and then only upon the burning material. Ordinary warehouse floors constructed to carry hops in their dry state are in most cases quite inadequate to sustain the enormous weight of the stock when saturated with water.

Hydrochloric Acid. (*See* Acids.)

Hydrogen. (*See* Gases.)

The two principal combustibles are hydrogen and carbon. Together they make up the great mass of all our fuels, such as coal, wood, oils, and burning gases ; and along with oxygen and nitrogen they form the greater part of all vegetable and animal tissues.

Hydrogen is a colourless gas without taste or smell, and is the lightest substance known. Its weight, as compared with water, is as a few ounces to a ton. It is fourteen and a half times lighter than air. It forms a ninth part by weight of water, the other eight-ninths being oxygen. Except for scientific and technical purposes hydrogen is rarely used in its pure state. But in combination with carbon and certain other matter it forms all the inflammable gases, such as coal gas, acetylene, water gas, producer gas, etc., and the liquids, petroleum, naphtha, petrol, etc.

Inorganic Compounds.

All chemical compounds excepting those of carbon, which are known as organic compounds.

Iron Foundries. (*See* Metals and Minerals.)

Iron (Powdered). (*See* Metals and Minerals.)

Jute. (*See* Cotton.)

Jute Mills. (*See* Factory Buildings.)

Kapoc. (*See* Cotton.)

A vegetable down exceedingly inflammable.

Kieselguhr.

A calcined infusorial earth, not dangerous. Used in the manufacture of dynamite.

Lamps. (*See* Fires of frequent occurrence, in Part I.)

Latent Heat. (*See* Heat.)

Lightning.

Whether lightning rods or arrestors should be fixed, and if so how, is a much-discussed question, and cannot be gone into in this book.

Lime.

Quick lime, caustic lime, or calcium oxide are synonymous terms ; and similarly slaked lime, hydrate of lime, or calcium hydroxide.

A small amount of rain or water falling on unslaked lime engenders great heat, and is often the cause of fires. This action is akin to some phases of spontaneous combustion.

If possible water should not be used when this material is involved in a fire. If water is brought into contact with lime in an enclosed space (such as a railway wagon) a temperature as high as 750° Fahr. is soon reached, and the woodwork ignited.

Slaked lime reacts more or less violently with strong mineral acids, and should not be stored where it may come into contact therewith. All lime should be stored above the floor level ; it requires careful handling, as it seriously injures skin and flesh when damp.

Liquids. (*See* Ether *and* Petrol.)

OILS, GREASE, FATS, VARNISHES, and SPIRITS require great care in extinguishing, most being lighter than water. A jet of water forced into a receptacle containing such burning material may scatter the fire and ignite the adjoining property. The water may also be converted into steam and produce a similar effect.

Should the receptacle be of moderate size a blanket, tarpaulin, asbestos sheet, or similar article may be drawn over the top, and if kept sufficiently tight upon the upper rim of the receptacle the air with its oxygen will be excluded and the fire extinguished. If it is possible to damp the sheet, etc., it will prove more effectual.

All fires under boilers and other lights sufficiently near to be dangerous should be withdrawn to a safe distance.

Dry sand or earth will absorb the liquid and reduce the heat, and also by excluding the oxygen of the atmosphere extinguish the fire. Where this is unobtainable the soil or ground may be loosened with iron bars to allow the liquid to soak in.

In addition to fire hazards at ordinary temperatures there is considerable risk of explosion if fats are subjected to heat above 500° F. Burning fats generate great heat which may liberate explosive vapours and gases from other fat that is near the burning material, but which is not actually alight. When subjected to heat above 500° F. vapours are given off which may even spontaneously inflame without the application of a light.

The storage of many inflammable liquids is regulated under the Defence of the Realm Regulations.

Magnesium. (*See* Metals and Minerals.)

Malt Mills. (*See* Dust Explosions.)

Manganese. (*See* Metals and Minerals.)

Margarine. (*See* Liquids.)

Melting Points. (*See* Appendix A, Table III.)

Menagerie (*See* Animals.)

Metals and Minerals.

If water is directed into a pan containing MOLTEN METALS, such as BISMUTH, COBALT, IRON, MAGNESIUM, MANGANESE, TIN, steam is rapidly evolved (sometimes resulting in an explosion), which scatters the heated materials in all directions, igniting surrounding property. This is owing to the strong affinity which certain metals have over oxygen, and sometimes hydrogen may be liberated by bringing such metals in certain conditions into contact with water. Thus, if a piece of the metal POTASSIUM, even when cold, is thrown on water it will combine with the oxygen, and evolve hydrogen, which will take fire owing to the heat produced by the chemical action. The same thing happens if SODIUM be used, except that in this case the hydrogen does not so readily take fire spontaneously. This power of resolving water into its gases belongs also to IRON and CARBON when very hot, and this is a most important consideration in the operation of a fire brigade, because the playing of water into a white-hot mass of carbonaceous matter and iron has simply the effect of setting free volumes of highly inflammable gases, unless the jet of water projected from a safe distance is large enough and strong enough to crush out the air, and to so cool down the fire until it ceases to burn. Sand or earthy material is often used in subduing such fires.

Many POWDERED METALS ignite on coming into contact with water: ALUMINIUM, BARIUM, BRONZE POWDERS, CALCIUM, IRON, MAGNESIUM, POTASSIUM, SODIUM, and ZINC are those generally met with, some more particularly since the introduction of "THERMIT" (much used for welding purposes). If these are in the proximity of a fire they should be removed as soon as possible to a position of safety. The heat engendered is very intense, and there is also the possibility of an explosion occurring. If there is but little risk of the fire spreading it is advisable to let it burn out, keeping strict watch that no other fire is started owing to the great heat.

CARBIDE OF CALCIUM is used for generating acetylene gas by being brought into contact with water. Its storage is regulated under the provisions of the Petroleum Act. ACETYLENE GAS is extremely explosive when mixed with air.

IRON.—An explosion may be caused in a PUDDLING FURNACE by cooling down the hearth with water.

PHOSPHORUS is usually kept in water, as when exposed to the atmosphere it inflames.

POTASSIUM will fire if brought into contact with water, and is usually kept in paraffin.

SODIUM will fire if brought into contact with water, and is usually kept in paraffin.

SULPHUR when alight spreads rapidly, but can be extinguished by a copious supply of water.

Methane.

Methane or MARSH GAS is an inflammable gas, generally associated with explosions in coal-mines. It is met with, however, in unexpected places, such as bins containing seeds or agricultural produce which has been allowed to decay.

Mines.

Fires at collieries should only be dealt with under instructions from the responsible manager. Those occurring on the surface are generally of an ordinary description, whilst the regulations of the various Acts of Parliament have to be borne in mind when dealing with those below ground. It may be said that there are four methods adopted by mining engineers for extinguishing fires underground : (1) "Filling out," by driving a road to the seat of the fire, applying water to quench the burning material, excavating it and removing it to the surface ; (2) "stopping off," by building walls across the roads leading to the seat of the fire ; (3) "drowning out," by flooding the particular area affected after it has been "stopped off" ; (4) using carbonic acid gas.

Motor Vehicles. (*See* Petrol.)

Munition and Explosive Factories. (*See* Explosives.)

Beyond the general rules for extinguishing ordinary fires not much guidance can be given as to the best method of dealing with fires in buildings in which explosives are stored. The general rule should be to go for the fire quickly ; you may be successful and put it out, and thus earn the goodwill of your fellow-men and a medal, or you may lose your life as many better men have done in trying to do their best.

Explosives are usually dealt with in buildings of light construction, and of a moderate size, having open spaces between them. Owing to their construction they are easily fired. An explosion in one will scatter burning materials all round the neighbourhood and fire other buildings, causing further explosions. Sympathetic explosions are also possible. In many cases, however, there is time between the fall of the brands to extinguish these flyers before further sheds are ignited.

Firemen attacking an explosive factory should be careful to see that all fire is extinguished as they pass along, and thus ensure, as far as possible, that an explosion will not take place behind them.

In explosive factories some buildings are classified as "danger" buildings, and should a fire have originated in such a building in the majority of cases it will almost certainly be wrecked by immediate explosion unless the explosives are such as will burn comparatively slowly for a short time without exploding, in which case the appliances which are at hand should be utilized and the hand drenchers turned on.

If a fire has originated in another building and threatens to involve a danger building, every effort should be made to extinguish the fire to prevent it spreading to the danger building, and the roof and walls of the danger building should be thoroughly wetted as also their explosive contents.

Some moderate protection, such as mounds or low walls, will probably be available within even 100 or 200 yards of danger buildings, under which those who are fighting the fire can take shelter if their efforts have not been successful and the fire is spreading to a danger building.

In H.M. Inspectors of Explosives Annual Report for 1916 the following passage appears :—

"Accidents. . . . The number of casualties is unfortunately very much higher . . . but it should be noted that no less than 144 deaths were due to 2 accidents, namely, 106 in one accident . . . and 38 in another . . . of the remaining 51, 7 were killed at . . . Works and 7 at . . . Factory, and it is hardly too much to say that all these 158 fatalities might have been avoided if instead of engaging in futile efforts to extinguish the fires the factory officials concerned had cleared everyone away from the neighbourhood."

Muriate of Tin. (*See* Stannic Chloride.)

Muriatic Acid. (*See* Acids.)

Music Halls. (*See* Theatres.)

Naphtha. (*See* Petrol.)

Nitrate of Potash. (*See* Explosives.)

Frequently called saltpetre or potassium nitrate.

Nitrate of Soda, or Chili Saltpetre.

It is not advisable to use water on Nitrate of Soda fires, as this causes the fire to scatter in all directions. Sand or dirt is best used for smothering fires of this description. Bags in which Nitrate of Soda has been stored are exceedingly inflammable and require a large amount of water to prevent the fire spreading.

Nitric Acid. (*See* Acids.)

Nitrogen.

A gas which does not support combustion. Any danger being purely that of explosion.

Nitro Compounds. (*See* Explosives *and* Munition Factories.)

Nitro compounds are explosives composed wholly or partly of (*a*) nitro-glycerine like dynamite, etc., and (*b*) chemical compounds possessed of explosive properties produced by the action of nitric acid upon any carbonaceous substance like T.N.T., picric acid, guncotton, etc.. These cannot be exposed for any length of time to an increase of temperature, even though this may be far below the igniting point without decomposition setting in. This chemical action develops more heat, which in turn increases the chemical action and so on, thus producing sufficient heat to cause explosion.

Nitro-Glycerine. (*See* Explosives.)

Freezes at about 46° F., and in that condition is thought to be more dangerous. It should only be thawed in the special apparatus made for the purpose.

Occlusion.

Some metals when subjected to considerable heat have the property of absorbing gases. This property is generally known as occlusion.

Oils. (*See* Liquids.)

Oleum or Fuming Sulphuric Acid. (*See* Acids.)

Omnibus with Petrol. (*See* Petrol.)

Organic Compounds.

All chemical compounds of carbon (except that carbon monoxide and carbon dioxide are generally considered as inorganic compounds).

Oxalic Acid. (*See* Acids.)

Oxide.

A compound of an element with oxygen.

Oxidizing.

Uniting with Oxygen.

Oxygen. (*See* Gases.)

Oxygen is not combustible by itself, but if there were no oxygen there would be no fires. The air is composed of the two gases oxygen and nitrogen ; by volume, 21 per cent of oxygen and 79 per cent of nitrogen, by weight, 23 per cent oxygen and 77 per cent nitrogen, and oxygen is the active gas of the air, so that when mention is made that a fire goes out for lack of air, or that a draught fans the flames, it is only the oxygen in the air that is considered. In view of the small proportion of oxygen compared with nitrogen it can be at once seen what powerful properties oxygen possesses.

Paper. (*See* Tobacco.)

Paraffin. (*See* Liquids.)

The storage is regulated under the Defence of the Realm Regulations.

Permanganate of Potash.

Should not be allowed to come into contact with glycerine.

Peroxide.

An oxide of higher degree than the ordinary oxide.

Peroxide of Sodium. (*See* Sodium Peroxide.)

Petrol.

PETROLEUM SPIRIT is commonly known as Petrol, although strictly speaking this name can only be applied to a spirit produced by one firm who have registered the word.

"Petrol is the first distillate from the crude oil as it comes from the oil well, and largely consists of pentane, $C_5 H_{12}$, and hexane, $C_6 H_{14}$, the first liquid members of the great paraffin group of hydrocarbons. This liquid is volatile even below the freezing point, and a pint of it poured on a level surface will cover about 80 square feet with an inflammable vapour, through which on coming in contact with a light a flame will spread. One pint of the liquid will also give enough vapour to render 100 cubic feet of air highly explosive."—LEWES.

Petrol is usually stored in 2 gallon iron cans fitted with screw caps, or in tanks. In some cases the receptacles are fitted with various safety devices to prevent any escaping vapour that may become ignited, setting fire to contents of the receptacle. The specific gravity of petrol being only about ·7 the spirit readily floats on water, while the vapour that is given off is about three times heavier than the air, and highly inflammable. The storage is regulated by the local authorities under the Petroleum Act and Defence of the Realm Regulations.

Petrol fires are seldom caused except by the contravention of the regulations, and are usually due to the careless way in which unextinguished matches are thrown down after lighting cigarettes.

Once a large quantity of petrol is alight it is almost impossible to extinguish it. All energy should be centred upon protecting the adjoining property.

Sand, earth, etc., will absorb the spirit, but the vapour will still be given off.

Water in the form of a spray may be used to cool down the surroundings to enable cans to be removed to safety before the heat has time to destroy the effectiveness of the joints of the can. A pole with a hook, or what is known by firemen as a preventer, is a useful implement for this purpose.

Sawdust, flour, or any light material that will float upon the surface of the liquid and thus exclude the air may be used with good effect. Sawdust can be rendered more effective if mixed with bicarbonate of soda (10 lb. of bicarbonate of soda to 8 gallons of sawdust). The mixture should be thrown on the burning liquid with an action similar to working a scythe, and by starting at one side of the fire drive the flame to the other, taking care not to let it light back.

Chemical extinguishers of the soda acid type may be used to keep the surrounding property cool, and in some cases the force of the jet of liquid from the appliance has been found effectual in knocking out the flame.

Chemical extinguishers employing carbon tetrachloride can also be used on such fires, the effect of the heat on the chemical generating a dense smoke which smothers the flame, but it must be remembered that the quantity of liquid available in these appliances is most limited and must be carefully applied. Care must be taken not to inhale the smoke, as sometimes chlorine gas is evolved.

MOTOR VEHICLES.—Should the fire be in a van or lorry, car, omnibus, or other motor vehicle on the high road, if possible shut off the petrol supply cock on the pipe from the tank, but if this cannot be done—especially if the vehicle is a tank-waggon for conveying petrol or petroleum and the petrol or oil is liable to spread—surround with dry sand or soil. If it is being carried in large quantities for trade purposes on a lorry towed by a steam tractor, shut off as above and draw the fire, or if possible disconnect and remove the tractor. The tank should in any event be kept cool by playing water on it.

If the engine is on fire (generally due to a flooded carburetter) one of the small chemical extinguishers filled with carbon tetrachloride can often be used with advantage. Frequently the fire can be knocked out with a cap, glove, or small rug. It is not advisable to use sand or earth, if possible, as this will damage the machinery. Small quantities of water are worse than useless.

Phenol or Carbolic Acid. (*See* Acids.)

Phosphorus. (*See* Metals and Minerals.)

Melts at 44° C. (111° F.), and ignites at a few degrees higher temperature.

Photographic Block Engravers. (*See* Process Engravers.)

Picric Acid. (*See* Dye Works, Explosives.)

Potassium. (*See* Metals and Minerals.)

Potassium Chlorate. (*See* Chlorate of Potash.)

Potassium Nitrate. (*See* Explosives.)

Also known as NITRE and SALTPETRE.

Process Engravers.

Employ large quantities of inflammable liquids and substances, including ethers, collodion, collodion cotton, resins, besides having a considerable amount of electrical apparatus and loose wiring in use.

Proof Spirit. (*See* Alcohol.)

Puddling Furnaces. (*See* Metals and Minerals.)

Pyrophoric. (*See* Wood.)

Quick Lime. (*See* Lime.)

Rags. (*See* Tobacco.)

Railway Trains.

The use of gas in lighting passenger trains has much increased the danger of fire caused by collisions, when the pipes are fractured and the woodwork and other combustible substances scattered about. As most of these mishaps take place away from stations, often far away from an organized water supply, and are attendant with casualties to passengers, the most that can be done by the uninjured survivors is to succour those in distress and endeavour, as far as possible, to localize the fire by removing unburnt material from the vicinity of the fire, and using tools and any chemical fire extinguishers that are upon the train or can be obtained, together with any water that may be at hand.

UNDERGROUND TRAINS.—All platforms, tunnels, and carriages should be kept as clear as possible of combustible materials, refuse removed as found, and any lockers, offices, or inclosures kept scrupulously clean.

The suggestions as to Electrical Fires should be observed, and upon no account should water be used until the railway officials are satisfied that all electrical current has been cut off.

Those portions of these undertakings containing the lifts and similar machinery require much care in supervision, and even a small smouldering fire can often only be approached by men equipped with smoke helmets or other similar outfit.

Reducing Agent.

A substance which removes oxygen.

Ricks. (*See* Agricultural Fires.)

Safety Lamps.

These lamps were originally designed by Sir Humphry Davy. The principle whereby safety is secured is due to the wire gauze by which the flame is surrounded being a good conductor, so that any heat is carried away faster than it is produced, and the temperature falls below that necessary to set the gas or vapour outside the lamp alight. If, however, the gauze gets too hot the safeguard principle fails. Care should be taken not to place the lamp on the ground if the gas or vapour sinks or overhead if the gas or vapour rises.

Saltpetre. (*See* Explosives.)

Also known as NITRE and POTASSIUM NITRATE.

CHILI SALTPETRE is SODIUM NITRATE.

Seed Cleaning. (*See* Dust Explosions.)

Seed Stacks. (*See* Agricultural Fires.)

Ships.

Special provision for dealing with fires on passenger ships was made in the Convention for safety of life at sea, signed at London January 20, 1914.

Ships differ so greatly in build and size, and the cargoes contain every kind of merchandise with their various attendant risks, that it is almost impossible to make any concise suggestions that could be considered applicable in any one case.

As a rule fires that occur at sea in any part of the ship but the hold can be extinguished by the men upon duty ; the anxiety of the officers is concentrated upon the unknown dangers in the cargo, more particularly as some of the merchandise may through one cause or another have been in a state bordering upon combustion when placed on board.

If the holds are well separated and the hatches air-tight it is usually best to make for port and obtain plenty of assistance, then open out the cargo or swamp the compartment.

Officers of fire brigades attending fires in ships should at once consult the captain and the officer who had charge of the loading as to the exact position and nature of the various commodities forming the cargo, and how they are stowed.

In port ships are often left in charge of watchmen only, and are therefore subject to the usual carelessness in dealing with lights, etc., the lamp-room being a particular source of danger.

Smoke helmets and electric lamps are invaluable for use in ships' holds, where gases, many of which are of the heavier kind (*see* Appendix A, Table I), are met with.

The critical moment, when fire-fighting with the hose and jet is deemed ineffectual and the order to swamp the compartment is given, is always an anxious one for the fireman in charge, and care must be taken that the vessel does not capsize.

Steam and certain gases, as mentioned in Part I, can sometimes be used with advantage.

Shops. (*See* Fires of frequent occurrence, in Part I.)

Shredded Timber. (*See* Wood Wool.)

Slaked Lime. (*See* Lime.)

Smokeless Powder. (*See* Explosives.)

Sodium. (*See* Metals and Minerals.)

Sodium Hydrate or **Sodium Hydroxide.**

Another name for caustic soda.

Sodium Nitrate. (*See* Explosives and Nitrate of Soda.)

Known as Chili saltpetre.

Sodium Peroxide.

If slightly wetted will cause a fire, generating intense heat. When used for bleaching straw and woollens it is dissolved in water, in the proportion of 1 lb. to at least 10 gallons of water.

Specific Gravity.

Specific gravity or COMPARATIVE DENSITY is the relation between the weights, at a fixed temperature, of any body, liquid, or gas, and that of an equal bulk of some other body, liquid, or gas taken as a standard.

The STANDARD FOR SOLIDS AND LIQUIDS is distilled water at its greatest density (nearly 4° C., or 39·2° F.).

The STANDARD FOR GASES is either air or hydrogen.

Specific Heat. (*See* Heat.)

Spinning Mills. (*See* Factory Buildings.)

Spirits. (*See* Ether *and* Petrol.)

Spirits of Salts or Hydrochloric Acid. (*See* Acids.)

Spontaneous Combustion.

This subject is so important and involved that it is specially dealt with in Appendix B.

Stables. (*See* Animals.)

Stacks. (*See* Agricultural Fires.)

Stannic Chloride.

Known as MURIATE OF TIN, used in dyeing and calico printing, is a colourless, caustic, and densely fuming liquid, boiling at 238° F. When mixed with water great heat is generated.

Static Electricity. (*See* Spontaneous Combustion.)

Straw. (*See* Agricultural Fires.)

Sugar of Lead (Acetate of Lead).

Poisonous.

Sugar Mills. (*See* Dust Explosions.)

Sulphur. (*See* Metals and Minerals.)

Sulphur Dioxide.

A gas which does not support combustion. Any danger is purely that of explosion.

Sulphuretted Hydrogen.

An inflammable and highly poisonous gas.

Sulphuric Acid. (*See* Acids.)

Tank Waggon. (*See* Petrol.)

Telegraph and Telephone Poles.

It is not advisable to cut the wires in the event of the poles being on fire.

Telephone Exchanges. (*See* Electrical Fires.)

Temperature. (*See* Heat.)

Tetrachloride of Carbon. (*See* Chemical Fire Extinguishers in Part I and Petrol.)

Theatres.

Many of the old theatres have been burnt down, some more than once, and in view of the regulations under which the new ones are built the fire risk should be reduced, but if the authorities allow portions of the buildings not fully separated from the theatre itself to be used as a carpenter's shop, scene store, or a manufactory for properties, most of the care taken during the construction of the building to make it fire-resisting will be annulled.

Upon arriving at a theatre on fire, at once ascertain whether any one is confined in the building, and, as in all other cases, find the seat of the fire and see that the fire-curtain (if any) is down, and the smoke outlets over the stage open. Smoke may prevent the location of the fire for some time, and as soon as the appliances are got to work upon the fire all skylights and windows should as a rule be opened to let out the smoke.

The fire-curtain is generally actuated by gear with control levers at both sides of the stage and by the stage door.

If scenery is alight "cloths" should be dropped on to the stage by cutting the supporting ropes and "wings" tipped over to fall flat on the stage.

Where stages are fitted with "drenchers" they should be turned on, no matter if the fire appears to be a slight one.

Thermal Unit. (*See* Heat.)

Thermit. (*See* Metals and Minerals.)

This is a mixture of approximately 75 per cent of powdered oxide of iron and 25 per cent of powdered aluminium. The ignition powder consists of a small quantity of a mixture of 66 per cent peroxide of barium and 33 per cent of powdered aluminium.

Thermometers. (*See* Heat.)

Timber in Flues, Hearths, and in Roofs. (*See* Fires of frequent occurrence, in Part I, Chimneys, Churches, and Wood.)

Timber.

STORES.—Timber when properly stacked for seasoning is of necessity in the best position for burning. Tackle a timber yard by first securing the safety of the surrounding property, and then working from the outside remove and wash each piece of timber before it is passed, thus working towards the centre of the yard. Much of the stock in the middle may be burnt, but the quantity on the outskirts saved will in value far exceed what the salvage would be if attempts were made to extinguish all the stack at the same time.

The greatest care must be taken that the least spark is not passed over.

VENEER for the use of cabinet-makers is cut from the finer varieties of wood by means of a very fine saw or knife, and as the oxygen in the air cannot readily get between the sheets when stored as they leave the cutting machine they burn at the edges only, more like stacked paper.

Woods used for veneer are valuable, and should be extinguished in bulk without interfering or separating the sheets if possible, and when space is available allow to cool without unduly wetting.

During the time veneer is burning a pungent gas is evolved, and this is readily inflammable, and may be ignited sometimes after the body of the wood is safe.

Tobacco.

TOBACCO, PAPER, RAGS, and similar goods when thoroughly lighted give off dense smoke and will absorb large quantities of water, and the bulk when saturated will be greatly increased in weight, possibly far beyond what the floors were constructed to carry; also the goods thus saturated will frequently be considerably swollen, with the consequent result that the surrounding walls will be fractured unless sufficient space has been arranged for this increase when storing.

Turpentine. (*See* Liquids.)

Turpentine Substitute or White Spirit. (*See* Liquids *and* Petrol.)

Generally a petroleum spirit with a low flash point and highly inflammable.

Underwood. (*See* Agricultural Fires.)

Vans with Petrol. (*See* Petrol.)

Varnish. (*See* Liquids.)

Vegetable Fibres. (*See* Cotton.)

Veneer. (*See* Timber Stores.)

Vessels. (*See* Ships.)

Vitriol, or Oil of Vitriol. (*See* Acids.)

Strong sulphuric acid.

Water Gas.

Water gas has no smell and is very inflammable, but less explosive than hydrogen, partly due to the nitrogen and carbon dioxide which it contains.

Water not to be used.

Water not to be used as a general rule to extinguish fires in which the following materials are involved :—

Calcium Carbide.	Oil.
Calcium Phosphide.	Paraffin.
Electric Fires.	Petrol.
Lime.	Spirit.

Wharves. (*See* Coal.)

Wild Animals. (*See* Animals.)

Wood.

"When wood is exposed to the long-continued action of heat it undergoes progressive changes nearly akin to those which have taken place during the conversion of vegetation into coal. Up to 100° C. (212° F.) practically only moisture is expelled from the wood, and at a few degrees above this point not only water but volatile hydrocarbons are slowly driven out, whilst at 150° C. (302° F.) oxides of carbon, together with more hydrocarbons, are disengaged, and slightly above this temperature the wood commences to assume a scorched appearance and to turn brown. At about 250° C. (482° F.) wood is converted into a soft brownish form of charcoal, which is its most dangerous form, being highly PYROPHORIC and self-igniting at comparatively low temperatures. At 300° C. (572° F.) the carbon begins to assume the appearance of soft black charcoal, getting harder and more metallic in its properties as the temperature increases.

"If the contact of the wood with the heated surface be continued for a sufficiently long period of time, a temperature of a few degrees only above the boiling point of water is enough to produce a semi-carbonized film on the wood, which will start smouldering at a very low temperature, the heat rising from an oil lamp or gas flame some distance away being sufficient to start the smouldering combustion. Indeed, the temperature of a steam-pipe has been found sufficient to cause ignition, this being due probably to the long-continued heat generating certain hydrocarbons of low ignition point, which remained occluded in the pores of the semi-charred wood, and are there brought into close contact with the occluded oxygen."—VIVIAN B. LEWES, Cantor Lecture, 1906.

	Cent.	Fahr.
CHARRING TEMPERATURE for fir . .	232°	450°
IGNITION TEMPERATURE for fir . .	316°	600°

ADAMS.

Wood Stores. (*See* Timber Stores.)

Wood in Buildings. (*See* Timber Stores.)

Wood Wool.

Shredded timber in the form of wood wool and similar material used for packing burns rapidly owing to the large amount of air-space, and as it usually is stored in a confined space will soon use up the oxygen in the air and leave the space filled with carbon monoxide, which is a heavy poisonous gas and not easily dispersed. The utmost care should be taken when about to enter buildings in which wood has been consumed, and where the lower portion is without adequate ventilation, as to inhale any carbon monoxide is most dangerous.

Woollen Mills. (*See* Factory Buildings.)

Zinc. (*See* Metals and Minerals.)

Zoological Collections. (*See* Animals.)

APPENDIX A.

TABLE I. DENSITIES OF GASES AND VAPOURS.

(Air taken as Unity.)

LIGHTER.		HEAVIER.	
Hydrogen	0·069	Oxygen	1·105
Coal Gas	0·040–0·60	Phosphuretted Hydrogen	1·185
Ammonia	0·588	Sulphuretted Hydrogen	1·192
Acetylene	0·898	Air Gas	1·260–1·317
Water (Steam)	0·956	Carbon Dioxide	1·519
Carbon Monoxide	0·967	Alcohol	1·613
Nitrogen	0 970	Acetone	2·0 (appx.)
		Chlorine	2·448
		Ether	2·565
		Carbon Disulphide	2·645
		Benzol	2·770
		Chloroform	4·215
		Amyl Acetate	4·6

TABLE II. EXPLOSIVE RANGES OF GASES WHEN MIXED WITH AIR.

	Per cent.		Per cent.
Acetylene	3·2–52·2	Ether Vapour	2·9– 7·5
Alcohol Vapour	4·0–13·6	Ethylene	4·2–14·5
Benzine Vapour	2·5– 4·8	Hydrogen	9·5–66·5
Benzol Vapour	2·7– 6·3	Methane	6·2–12·7
Carbon Monoxide	16·6–74·8	Pentane	2·5– 4·8
Coal Gas	8·0–19·0	Water Gas	12·5–66·6

TABLE III. MELTING POINTS.

	Cent.	Fahr.		Cent.	Fahr.
Sulphur	112	235	Copper	1083	1981
Tin	232	450	Iron	1520	2768
Lead	327	621	Platinum	1755	3191
Zinc	419	786	Iridium	2300	4170
Aluminium	658	1217			

U.S.A. Bureau of Standards.

TABLE IV. COLOURS CORRESPONDING TO TEMPERATURE.

	Cent.	Fahr.		Cent.	Fahr.
Lowest red heat visible in the dark	325	635	Orange	1100	2010
Dull red	700	1290	Bright orange	1200	2190
Brilliant red	800	1470	White heat	1300	2370
Cherry red	900	1650	Bright white heat	1400	2550
Bright red	1000	1830	Dazzling white heat	1500	2730

Becquerel.

TABLE V. BOILING POINTS.

	Cent.	Fahr.		Cent.	Fahr.
Petroleum Ether	36–70	97–158	Coal Tar Benzol	80	176
Acetone	55	132	Sulphuric Acid (Chamber)	130–338	266–640
Carbon Tetra-chloride	77	170	Oil of Turpentine	152–160	305–320
Alcohol	78	172	Camphor Oil	204–300	407–572

TABLE VI. FLASH POINTS.

	Cent.	Fahr.		Cent.	Fahr.
Carbon Disulphide	–20	–4	Collodion	5	40
Ether	–20	–4	Amyl Acetate	18	65
Petroleum Ether	–20	–4	Brandy, Whisky, and Gin	28–32	82–90
Coal Tar Benzol	–15	–4			
Acetone	2	35			

APPENDIX B.

SPONTANEOUS COMBUSTION.

May be defined as the "ignition by the internal development of heat without the action of an external agent.

"The action is as follows: Porous substances absorb air, oxidation raises the temperature, which in turn accelerates the oxidation with increasing rapidity until fire ensues. The low conducting power of porous substances greatly facilitates combustion by preventing the dissipation of the heat generated.

"Oxidation always produces heat, but most frequently in such small quantities that it is imperceptible. Nevertheless, however slight the heat evolved in the oxidation of a substance may be, if confined it will usually in time raise the temperature of the substance undergoing oxidation to the point of ignition resulting in fire. Chemically, therefore, a fire may be described as oxidation at a temperature at or above the point of ignition of the oxidized substance, also as a phenomenon due to combustion or oxidation of a substance evolving heat and light.

"Moisture is a factor in nearly every known case of spontaneous ignition.

"The amount of heat generated is precisely the same in slow as in rapid combustion of equal quantities of material, but in slow combustion it is unnoticeable. One form of slow combustion is the rusting of metals, principally iron, which in the form of fine borings, filings, and turnings exposed to the elements in large quantities will cause a decided rise in temperature through oxidation.

"Another example of slow combustion is that of respiration, the fuel being the non-nitrogenized substances, as starch and sugar consumed as part of the sustenance of human beings, the amount of heat produced being the same as would be set free by burning. Therefore ordinary combustion, decay, and respiration are chemical processes differing only in the rapidity and completeness with which they occur, and the products of combustion, decay, and respiration are chiefly carbonic acid gas, water, and ammonia.

"Various substances have an affinity for oxygen to a greater or smaller degree, and the chemical action is therefore more rapid in some mixtures than in others.

"All vegetable oil will cause spontaneous ignition if it has the property of drying by reason of absorbing oxygen, and animal oil will cause spontaneous ignition if it has the property of becoming rancid."

As an illustration the following experiment was made: Some cotton waste was saturated with boiled linseed oil at a temperature of 70° F. and placed in a stout paper box; after $4\frac{1}{2}$ hours the temperature was 80° F., after $5\frac{1}{2}$ hours 150° F., 6 hours 420° F., and after 6 hours 15 min., when the box was opened, the temperature was 440° F., and the cotton waste charred entirely through.

"Bacteria or micro-organisms are thought by some people to be responsible for some fires, the heat being produced by fermentation or putrefaction."

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"Although the temperatures produced by such actions are not high, yet if the heat cannot escape, a gradual rise in temperature results, which in turn accelerated the fermentative action and may cause the ignition point to be reached. An excellent example of such heating is afforded in heaps of stable manure or tanner's refuse. Any form of decaying organic matter may give rise to a similar effect in the absence of ventilation. Such heat, of course, could never be obtained if the mass were loosely piled so that air could freely circulate. On a larger scale this heating action is frequently observed in hay-stacks when the hay has been put away green or imperfectly dried. The micro-organisms so plentiful in grass and hay act on the fibres of the hay, producing oxidation and consequent heating (the initial heat developed by the organisms is not high, for most bacteria are destroyed below 212° F.). Here, again, a free access of air would prevent undue heating by allowing the heat to escape as fast as it is generated ; or if the hay were pressed into bales, and the air thoroughly squeezed out from the interstices, heating would be prevented. It is the presence of a limited amount of air that causes heating. On the other hand, it is not always desirable to entirely prevent fermentation, for by this means the aroma, flavour, and colour of the hay are improved. The addition of salt is frequently the only precaution a farmer takes when storing away his supply of hay. The salt retards the action of the bacteria and renders the hay more palatable.

"Summarizing, it may be said that some of the most fruitful sources of spontaneous combustion are to be found in the oxidation of certain rapidly drying oils where spread out on waste rags, etc. ; the oxidation of iron pyrites in soft coal ; the slow oxidation of heaps of organic matter, as manure and hay ; the absorption of gases by porous bodies, such as charcoal and powdered slack coal. In the above cases thorough ventilation or else none at all is to be recommended, a moderate or sparing admission of air tending to accelerate rather than to retard the action.

"As other sources of spontaneous combustion may be cited the action of nitric acid and other strong acids on organic matter (such as straw and shavings), the interaction of sulphuric acid and chlorates, the action of water on calcium carbide, sodium peroxide, and sulphuric acid, and the electric spark."—G. H. P. Walker.

This last source is generally referred to in these conditions as the generation of STATIC ELECTRICITY, and is mostly met with in dry-cleaning establishments.

APPENDIX C.

SOME ACTS OF PARLIAMENT REFERRING TO FIRES, FIRE BRIGADES, ETC.

YEAR.	TITLE OF ACT.	SECT.
1772	Dockyards Protection (*Arson*)	—
1774	Fire's Prevention (Metropolis)	86
1799	Arson	—
1833	Lighting and Watching	9, 41, 44, 61.
1847	Waterworks Clauses Consolidation	38–43.
1847	Towns Improvement Clauses	—
1847	Town Improvement (Ireland)	—
1847	Towns Police Clauses	5, 14, 30, 32, 33.
1854	Towns Improvement (Ireland)	52, 73.
1861	Malicious Damage (*Arson*)	—
1861	Criminal Law Consol. (*Arson*)	12, 30.
1867	Poor Law Amendment	29.
1875	Local Government Amendment	202, 233, 276, 285.
1875	Public Health	4, 66, 157, 163, 171, 182–6, 202, 233, 276, 285, 308.
1878	Public Health (Ireland)	76.
1888	Local Government	—
1890	Police	—
1890	Public Health Amendment	—
1892	Burgh Police (Scotland)	260, 291–9.
1893	Police	1–2.
1894	Local Government Amendment	5, 6, 7, 19, 57.
1894	Local Government (Scotland)	24.
1895	False Alarms of Fire	—
1896	Locomotives on Highways	—
1898	Local Government (Ireland)	—
1898	Parish Fire Engines	1–2.
1901	Factory and Workshops	14–16.
1905	Railway Fires	—
1907	Public Health Amendment	2, 3, 87–90, 308.
1908	Local Government (Scotland)	—
1908	Children's	15
1913	Fabrics (Misdescription) Act	—

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1917/8	Defence of the Realm Regulations	55B.

Note.—Some of the superseded enactments are included in this list.

In addition to the above, the following towns have special Acts relating to fires and Fire Brigades; Aberdeen, 1862; Ashton-under-Lyne, 1 49; Belfast, 1845; Birmingham, 1883; Dublin, 1862; Dundee, 1882; Edinburgh, 1879; Gateshead, 1887; Glasgow, 1866; Greenock, 1910; Isle of Man, 1886; Leeds, 1842; Liverpool, 1842, 1843, 1843, 1844, 1862; London, (Metropolitan), 1865, 1888, 1900; Manchester, 1844, 1866; Newcastle, 1865, 1870; Salford, 1862; Stockport, 1847; Tynemouth, 1866.