Fire Research Note No. 711

FIRE RESEARCH AND ITS IMPACT ON SOCIETY

by

D. I. LAWSON, M.Sc., C.Eng., F.I.E.E., F.Inst.P., M.I.Fire E.

May, 1968.

FIRE RESEARCH STATION

Fire Research Station,
Borehamwood,
Herts.
Tel. 01-953-6177

F.R.Note No. 711

FIRE RESEARCH AND ITS IMPACT ON SOCIETY

by

D. I. Lawson, M.Sc., C.Eng., F.I.E.E., F.Inst.P., M.I.Fire E.

SUMMARY

Fire Research is helping to reduce the direct loss by fire and also the national investment in fire by improving fire-fighting and making sure that building regulations and standards in general are designed rationally for the fires that occur in practice. It is shown that in this way savings can be made. Various new developments in the field of detection, fire-fighting and in the measurement of the impact of propaganda for fire prevention are discussed. The paper emphasizes once again the need for a 'systems' approach to fire protection which has been advocated by the Fire Research Station in the past.

FIRE RESEARCH AND ITS IMPACT ON SOCIETY

by

D. I. Lawson*, M.Sc., C.Eng., F.I.E.E., F.Inst.P., M.I.Fire

Twenty-one years ago, the Fire Research Station came into being as a partnership between government and insurance. It had a staff of some 25 all told. In the intervening years, the need for this kind of work has become so apparent that the staff is now over 170 and I should be very surprised if the national effort on fire research does not increase markedly in the future.

The Fire Research Station is now paralleled in other countries by stations with whom it has the closest association. Indeed, other countries have joined us on the larger and more complex research programmes so that we can all use our resources to the greatest advantage.

IMPORTANCE OF FIRE RESEARCH

Why should fire research be so important to a nation? Clearly in the first place it should help to reduce fire losses and direct losses of over £90 million per annum in the United Kingdom have become a matter of great concern. Fire disorganizes industry and while it is difficult to be certain of the precise cost of this disorganization, most estimates seem to put it as least as high as the direct loss.

This is only one facet however, for the United Kindom invests money to prevent fires in a number of ways. It operates a fire service both in the public and private sector which together cost £95 million per annum. The design of buildings is conditioned to some extent by fire and the extra cost attributable to fire protection amounts to about £70 million per annum. The administration of insurance with its various technical services costs another £65 million per annum, so that the total is well over £300 million per annum. At this level of spending, it is worth-while carrying out research to insure that the emphasis on the various investments is right.

You will see that there are two kinds of spending, direct loss and investment to prevent loss, and, judged by the national outlay, research into

---

*Director, Fire Research Station of Ministry of Technology and Fire Offices' Committee.

the deployment of preventive measures is at least of equal importance to that of reducing losses. Over-spending on preventive measures is unnecessarily restrictive as well as wasteful and can be just as bad as the effect of the fire loss it is supposed to counter. Under-spending, on the other hand, can also be wasteful because this can mean that the inadequate fire prevention measures already taken are often useless. Therefore one of the functions of fire research is to examine the hazard and make sure that the standards of performance are adequate.

Only last year, it was found from tests[1] that a fire would not propagate from one burning car surrounded by other cars in a multi-storey car park, even when left to burn without the intervention of a fire brigade (Fig.1). Surrounding unprotected steel structural members did not attain a temperature at which they would begin to lose strength, even though some of them were of light construction. This work showed that unprotected structural steel could be acceptable for multi-storey car-parking and this ought to result in a saving in the United Kingdom of about £375 000 per annum as compared with present forms of construction. This single item alone would continue to pay for the cost of running the Fire Research Station at its present level of staffing.

Another example of how fire research can save money is in the protection of equipment used in flammable atmospheres. A few years ago, we started to carry out work on flame arresters[2], because it seemed important to understand how these should be designed to prevent a low grade explosion in flammable vapour-air mixtures in ducts. A flame arrester is simply a corrugated metal ribbon bound in a helix, and if an explosion occurs on one side, heat is abstracted from the flames as they pass through so that any flammable vapour-air mixture on the other side cannot be ignited. It is in fact an application of the principle of the Davy safety lamp. One of the problems of modern industry is that electrical equipment is often used in atmospheres that may become flammable and where an electric spark could lead to a disastrous explosion. A way out of this is to surround the equipment with a metal box but the flammable gas can enter the box at joints, so the box ought to be strong enough to contain an explosion and the joints must be protected with accurately machined flanges so that if an explosion occurs, flames are cooled as they pass between the flanges. This equipment is very expensive.

Recently the Fire Research Station developed the idea of placing flame arresters in the side of the box so that, should an explosion occur in the box, it would not be propagated outside. Because the pressures inside the box are relieved, the box can be made of conventionally lightweight materials and the joints need not have any special machining. With an electric motor, the box is the motor casing and the flame arresters are placed in the side. (Fig.2). The saving on the cost of electric motors ought to amount to about £$\frac{1}{4}$ million per annum.

These are two recent examples of the way in which fire research can help the economy; others will become apparent later. It is really a matter of knowing what standard of performance is necessary and designing to meet the standard.

If a country has standards in which other countries have confidence because they are backed by sound technical appraisals, the equipment which the country manufactures must find a more ready sale in other countries and this is a bonus which can be added to the other savings.

British insurance has a long history of technical investigation behind it. In fact, the Fire Offices' Committee had a testing station in operation 62 years before the Fire Research Station came into being and I think that this has played its part in establishing the prestige of British insurance.

I have dealt at length with the motives for carrying out fire research because it is important to get these clear. The reduction of fire losses appeals to insurance and to governments, though government legislation is at present based on the saving of life rather than of property. Governments are also interested in minimizing the investment in fire prevention measures and in freeing restrictions on trade and industry; these are not the prime concern of insurance. The reluctance of the central government to legislate for a reduction in fire loss is bound up with the inability to evaluate the return for an investment in fire protection. In some countries the interests of insurance and government in fire research are separated. My own belief is that it is highly beneficial if they are concentrated together in one unit. This makes for a strong Research Station and a well co-ordinated research programme.

STATISTICS AND OPERATIONAL RESEARCH

When working on a subject such as fire research, it is important to find out as much as possible about fires as they occur, how they are fought and, above all, what they cost, for, saving of life apart, it is the saving of money that is the motive for most undertakings. The Fire Research Station collates information on between 150 000 and 200 000 fire reports sent in annually by the fire services. Reliable statistical information is necessary because however good the laboratory experiments, there are operational features which cannot be built into them, nor will it be possible to represent the interplay of such factors as static fire precautions and active fire-fighting.

Statistical information on causes of fires gives some idea as to where new hazards are arising. For example, if the number of fires ~~is beginning to rise~~ pro rata with the usage of fuel is beginning to rise, then it is probable that the equipment burning the fuel is becoming less satisfactory. The incidence of fires in relation to fuel consumption also enables forecasts to be made of the future fire picture once the fuel policy is known (Fig.3).

Statistical records on times of attendance of fire brigades[3] (Fig.4), immediately reveal whether there is any delay during rush hours; there is no indication of this at present, in fact attendances are marginally slower than average in the early morning.

Times of attendance can give an idea as to how fire stations should be sited. The Fire Research Station completed a survey of Bristol, bearing in mind the types of equipment that would be used on various journeys and the frequency of journeys made by fire appliances[4]. The information was fed into a computer which was programmed to choose the sites which would give a minimum attendance time from those available on the market. This type of work concerned with the administration of the Fire Service has now been taken over by the Scientific Adviser's Branch of the Home Office which is carrying out a similar exercise for Glasgow.

Since 1965 we have been receiving information on fires which individually cost more than £10 000 from the British Insurance Association. These are cross-linked by the Fire Research Station with the information obtained from the fire brigades on the fires they attend. We thus have the cost of fires linked with information on the cause, attendance time of brigade, the type of occupancy, the type of industry, the amount of fire-fighting that occurred, etc. and this provides a rich fund for investigation. Once this information is available, preferably on fires at a lower level than the £10 000 we are getting at present, it will be possible to see to what extent time of attendance at fires is a factor in determining their losses. The indications, so far are that it has a very weak effect. This is no doubt due to the fact that most fires are not being discovered early. It should be possible to see how much money is being destroyed by fire in relation to the time the fires are burning, which will give an indication of the value of investing in detectors or sprinklers. The duration of fires in various occupancies should give an idea as to the necessary fire-resistance that ought to be built into buildings when fire-fighting is taken into account, and this has not been considered in our present Building Regulations.

Quite apart from financial considerations, it is possible to study fire spread by examining fire records and this has the advantage of taking fire-fighting into account. If a fire breaks out in one part of a building, there is a finite probability that it will spread to other parts. The probability depends on the fire-resistance, and whether doors are left open, etc. In fact, the problem is similar to the spread of disease by epidemics for the mathematics are the same and it is a method of evaluating Building Regulations in practice that is bound to become more important in the future.

Perhaps I have given you sufficient instances to convince you of the importance of a good statistical background, but there is yet another. The number of outbreaks of fire is rising at about 6 per cent per annum and about three out of every four of these is caused by the failure of human beings to apply information that is already known. It is necessary, therefore, to know what influences the public in fire matters. The manufacturer has his sales charts but people interested in fire protection can only have fire statistics. We have tried to make some preliminary measurements[5] about what the public knows about fire (Table 1) as this will avoid publicity becoming platitudinous, but this is only a first step. The fact that a man knows something does not mean that he will act upon it. He may know that it is generally considered to be dangerous to drive more than 30 miles an hour in a built-up area, but other motives will at times make him disregard this, and so with fire publicity it is necessary to appeal in the end to statistical information on changes in the numbers and kinds of fires to see whether or not campaigns have had an effect. Recently we have been trying to establish what effect a fire campaign in Leicester last year has had on the fire statistics of that city. In spite of the intensive campaign, no significant effect was observed on the incidence of fire and it appears that fire propaganda is not yet very effective.

Table 1

Public knowledge about fire

Equipment	Public Action
Use of fire guard	46 per cent always use 20 per cent occasionally use
Control of electric heaters	85 per cent switched off at plug 17 per cent appliance only
Fire extinguisher	92 per cent look for red
Summoning Fire Brigade	**Public Action**
Method of calling brigade	88 per cent say use telephone 4 per cent ask neighbour 2 per cent shout 'fire'
Method of using phone	90 per cent know 999 code 8 per cent ask operator
Content of message	75 per cent know information required

Once information on fire losses is available, it is possible to establish upper limits of investment in fire propaganda. One of the most common causes of domestic fires is cooking; fires in cookers account for a loss of about ~~2½d~~ 5d per head of population as indicated by a survey[6] of fire losses in Surrey. The upper limit of investment, if the reponse were 50% effective ~~completely favourable~~, would therefore be 2½d per head of population. A survey[7] of the effectiveness of fire propaganda on cooker fires has also been made in Exeter. The results of this survey together with knowledge of the <u>per capita</u> loss should enable a cost-benefit analysis of propaganda in this field to be made. Studies are also being carried out into the variation in outbreaks of fire following house-to-house visits by some fire brigades to give householders information on fire protection matters.

Statistics and operational research is therefore a very powerful tool in fire research and I think this is proved by the interest shown in many countries in the systematic collection of information about fires.

STUDIES OF THE TIME-TEMPERATURE HISTORY OF FIRES

The history of a fire in a compartment can be characterized by three periods. In the first the fire is growing so that the flames envelop the whole compartment. The fire then burns steadily during the second period and the third period is one of decay in which the fire is dying down until it is finally extinguished. These stages have a descending order of importance.

The first and most important period of a fire is that in which the fire is growing and it is at this stage that human life is likely to be imperilled, property lost and the size of the fire on the arrival of the brigade determined. Unfortunately, it happens to be the most difficult to study, but recently some advances have been made. For example, it is known that once the flames reach the ceiling of a compartment the fire develops very rapidly. The flames then lengthen and the radiation from the long flames causes the compartment to become rapidly involved in fire (Fig.5). The fact that the flames lengthen, once they reach the ceiling, is due to the difficulty of mixing the cold air underneath the flame at ceiling level with the hot combustible gases in the flame; the flame has therefore to lengthen to complete the combustion process. Combustible ceilings increase the flame length by pouring combustible gases into the flame and making the oxygen deficit greater. The behaviour of the ceiling is thus most important in the spread of fire, and ceilings should either be non-combustible or nearly non-combustible. The spread is therefore likely to be most rapid in compartments with low ceilings. It is possible that the spread of fire at ceiling level might be halted by roof-venting or by the combination of roof-venting with water curtains; this is being investigated.

The second period, the one in which the fire is burning steadily, is important in saving the structure of the building, for it is the duration rather than the temperature of fires which brings about structural collapse. The duration of fires depends on the amount of fuel to be burned, and the rate at which air can get to the fire[8]. If the window openings are small in relation to the floor area, the duration of the fire is determined by the amount of fuel and the area of the window openings. If, on the otherhand, the window openings are large, so that the fire is well-ventilated, then the rate of burning, and thus the duration, no longer depends on the supply of air but on the amount and nature of the fuel (Fig.6). You will see, therefore, that the fire-resistance necessary for buildings is determined by this second period of the fire. Studies of both of these stages have been the subject of a concerted attack by a number of countries working with the United Kingdom.

The third period is relatively unimportant. The efforts of the fire brigade will always hasten the end of a fire once control has been obtained and the cooling down is likely to be rapid.

The work we have carried out on the duration of fires has enabled us to produce time-temperature curves for a number of real fires with different fuel loads under various ventilation conditions[9]. These time-temperature curves are different from those used by most countries in furnace tests and work has been carried out lately to relate the effects of both these time-temperature curves on structures[9], as the temperatures used in fire-resisting testing in furnaces have of necessity to be rather different in character. The main difference is that the temperatures obtained in real fires in buildings tend to be higher than those used in furnace tests, and there is the possibility that a cladding which might melt in a real fire could survive the furnace test. It would be worth-while, therefore, carrying out some small-scale preliminary tests in a muffle furnace to ensure that this would not happen before carrying out a furnace test. Apart from this proviso, the severity of the furnace tests is comparable with that obtained in building fires.

I have dealt at length with fires in buildings because these are the most important type of fire; they imperil life and generally cause the largest fire losses.

FOREST FIRES

Happily we do not have large forest fires in the United Kingdom, though these can be important in other countries. There is also, however, the possibility of conflagrations due to military action and these can be represented by conflagrations in forest fuels. We have therefore carried out some work on the growth of fires in the open and have succeeded in modelling their main features[10] (Fig.7), as full-scale fires can be extensive and costly to carry out.

PERFORMANCE OF STRUCTURES IN FIRES

We no longer build by simply supporting beams on walls and yet we all carry out our fire tests in a way appropriate to this form of construction imposing vertical loads only. In modern buildings, beams are constrained by lateral forces and by moments imposed by the structure and the problem of testing becomes very complicated. It is first necessary to compute the forces and moments likely to be imposed on a frame affected by fire by the rest of the building and then to apply these in a furnace test. This involves very difficult and complicated calculations and to avoid these the construction of parts of buildings with facilities for heating various parts of the structure under load has been considered. This would necessitate the construction of representative parts of buildings for every fire test and would present severe practical problems but only moderate theoretical ones. On balance, the difficulties in trying to compute the conditions for loading and restraining single elements in a flexible, though a more or less conventional furnace, would probably yield more information in the long run on the performance of structures in fire. A furnace of this kind would be very costly and perhaps it might be used as an international facility.

More needs to be known about the magnitude of the forces likely to be developed and, as a separate programme, the effect of constraints on structures.

Last year a study was made[11] of the use of a slightly elevated pressure in corridors with a view to keeping escape routes free of smoke and toxic gases. An excess pressure of about 0.1 in water gauge was found to be adequate to prevent smoke escaping from the cracks round doors if fire broke out in a room leading into the corridor. The excess pressure also had the effect of considerably improving the fire-resistance of the doors. Combustible doors usually fail because the fire exploits the crack between the door and the frame but this was prevented by the inflowing air.

FIRE DETECTION AND EXTINCTION

It is interesting to compare the times of occurrence throughout the day of large fires with those of fires in general[12] (Fig.8). The curve for large fires lags about five hours behind that for the smaller fires and this information, coupled with the fact that over half of the large fires in a sample of 1200 were discovered by people not actually on the premises, can only suggest that fires which become large burn for a long time before they are discovered. It is not, therefore, so important to design a detector system which will operate in seconds rather than in minutes, as to design one which will work reliably and will be sufficiently cheap to persuade industrial concerns to install it on their premises.

Fire detectors are at present cheaper to install than sprinkler systems and when it is borne in mind that in the Metropolitan Boroughs an attendance is made four times out of five by the fire brigade within three minutes of being called[3] (Fig.9) and it is in the Metropolitan areas that the main fire losses occur, then if fire detection systems are reliable, they should provide a valuable means of reducing fire loss. It must be remembered that about one-fifth of all the fires that subsequently become large were detected promptly and the brigade called without delay, so that detection alone will not cure the problem of large fires, but it should bring about a dramatic reduction in fire loss.

Some doubt has been cast on the reliability of the detection systems in use at present in that while there is no suggestion that they are missing fires, they are reputed to give false alarms. The detection systems which have the approval of the Fire Offices' Committee conform to rigid standards for reliability and freedom from false alarms; perhaps it is the communication system to the fire brigade that is not above suspicion. Further information is being sought by obtaining the records of false alarms from fire brigades and trying to locate the source of the fault.

Wire communications are expensive, about £20 per mile per annum in the United Kingdom and moreover this type of communication, if generally employed, would impose terminal problems at the fire stations. Efforts have been made to overcome this difficulty by a form of multiplexing. A simpler and cheaper system would be to use a radio link from each factory with an automatic sender giving, say, a three-letter code or working on a common frequency that could be picked up at a fire station watch room, which is already manned for receiving radio signals. A single frequency would be adequate to cover the United Kingdom, and though frequency space is difficult at present, our mounting fire losses of over £90 million last year must surely make the provision of such a frequency a matter of urgent consideration.

A development which would cheapen fire detection systems would be to have surveillance over a whole area. It would be worth about a shilling per square foot in large areas to overcome the wiring complications of point detection. Possible ways of bringing about this are to use infra-red detectors with some kind of scanning system and at the Fire Research Station we are at present considering the possibility of using laser beams[13]. Their highly directional properties allow a fire to be detected by the bending of the beam due to the change in refractive index of the air near a ceiling following the mushrooming of hot plumes rising from a fire, or alternatively by the scattering of laser beam light by smoke particles (Fig.10). Laser beams are particularly interesting in this connection because the main scattering effect is at very low angles of scattering; a highly collimated beam is therefore necessary if the scattered radiation is to be detected. Yet another possibility is to use the coherence of a laser beam to obtain interference between light that has travelled through a hot path near the ceiling and light that has travelled over a cooler path a small distance below. If a photo-electric cell is placed at the receiving point, interference bands will sweep over it as the temperature near the ceiling rises and an alternating output will be obtained which might be used to trigger an alarm.

Extinction, apart from sprinkler systems, is of secondary importance to detection, but fires will always have to be extinguished and it is therefore important to find the best method. Water is an ideal extinguishing agent as it is non-toxic, has a great capacity for heat and is so cheap (costing pence per ton delivered) that it is difficult to find another extinguishing agent to supplant it. The nearest chemical rivals, vaporizing extinguishing agents, cost shillings per pound, so they have a built-in 10 000 : 1 cost factor operating against them and their use will probably always be reserved for special risks. Perhaps if such an admirable substance as water had been dearer, we would have been forced to find out how to use it more economically earlier, and I think that future developments will lie in this direction.

Many of our large fires have to be fought blind. Quite a small fire will smoke-log a building so that it is impossible to locate the fire, and I do not see any possibility within the foreseeable future of providing firemen with an apparatus that will give them vision through smoke. About twelve years ago, at the Fire Research Station, we demonstrated an equipment which could locate a fire in a large open space[14]; it was simple and used an infra-red detector. We abandoned this at the time because we felt that it would not be useful in building complexes, but I think it could have a use in directing fire-fighting to the best advantage (Fig.11). If, for example, the temperature of smoke coming out of windows was measured by pointing such a device at the window, then the fire-fighting could be concentrated where the smoke was hottest and therefore nearest the fire. An alternative approach would be to use roof venting to let out the smoke and hot gases from the fire. Considerable work has been done on roof-venting design and this is attracting attention in a number of countries.

The use of high-expansion foam in which water is expanded to about a thousand times its original volume can be used to prevent air reaching a fire. The foam acts mainly as a seal and the fire is extinguished. It is quite feasible to fill whole compartments with foam in this way, but the stability of such foams should however be evaluated in fire conditions. There are indications that they break-down rapidly under radiation and once this happens, the air in the foam becomes available to the fire[15]. Just how important this is remains to be seen, but I suspect once the flames start running under a ceiling (you will remember I said this was the transition point between a small and a large fire) I think it probable that highly-expanded foams would collapse. If this were so, it would limit their use to the fighting of fires in their early stages. In the United Kingdom we have been using inert gas filled foams for fire-fighting, produced from the exhaust of a modified gas turbine[16]. Such foams if they did collapse would supply inert gas to the fire. An equipment of this kind is at present being developed by Rolls Royce.

Recently, we have carried out experiments using 'light' water[17] and this is apparently twice as efficient as protein foams, judged on the basis of the weight of solution required to control a fire. It is also very costly but the advantages in efficiency will often override the extra cost.

I mentioned that vaporizing liquid extinguishing agents will probably always be reserved for special risks, but this does not mean that they could not be made more effective. The action of a vaporizing liquid extinguishing agent is to interfere with the combustion process; more reactive extinguishing agents could probably be used but unfortunately, they tend to be toxic. A way of getting the best of both worlds would be to encapsulate highly reactive agents so that they would only be released in a flame and therefore pyrolized. It would be possible to neutralize the toxic products of combustion, i.e. the halogen acids, by mixing with the capsules a compound such as, say, urea which liberates ammonia on being heated and thus provides a neutralizing agent.

Dry powders are also important extinguishing agents. Recently the effect of particle size of powders likely to be used in fire extinction has been studied[18] at the Fire Research Station and has been shown to vary with the chemical considered so that powders which are not particularly efficient at one size range may become very effective at another. So far both mono- and di-ammonium phosphates have been found to be very efficient at particle sizes below 50 microns.

CHEMICAL ASPECTS OF FIRE

The United Kingdom, in common with other countries, has a rapidly growing plastics industry. The use of plastics in buildings is increasing at something like 16 per cent per annum, and this poses questions as to whether these materials may release toxic products in a fire. It is not sufficient to devise a plastic that will not burn itself, but as it is likely to be used in combination with other materials, it must not release toxic products when involved in a fire. The most important plastic in the building industry is polyvinyl chloride and this releases hydrochloric acid when involved in a fire. The hazards of hydrochloric acid must be evaluated against those of carbon monoxide with which we are already familiar (Fig.12).

The indications are that plastics used in thin sheets such as wall-papers are not likely to give rise to toxic hazards. Where greater thicknesses are employed, the relative toxicities of carbon monoxide and hydrochloric acid will depend on the degree of ventilation. For ill-ventilated fires, carbon monoxide will be dominant, but where the ventilation is better, hydrochloric acid will present the greater risk. It must always be remembered, however, that whereas carbon monoxide is insidious, hydrochloric acid gas readily makes its presence known and is likely to be less dangerous on this account.

Many industries produce dusts of one kind or another either as an end-product or a by-product of milling, cutting or grinding operations. Many of these dusts are produced as food-stuffs, cocoa, flour, soup powders, starch, or as cosmetics, or yet again as pharmaceuticals. So far, dusts have been classified in three ways by H.M. Factory Inspectorate of the ~~Ministry~~ Department of Employment and Productivity, depending on the size of the source of ignition.

As a result of experiments with large-scale apparatus, some of which is of industrial plant size (Fig.13), it has been shown that the dusts can be reclassified[19] and the effect has been to recognize that some dusts, formerly thought to be moderately dangerous, present little hazard. It is believed that perhaps the new classifications are conservative, but whether or not it would be worth-while undertaking research in this direction would depend on the economic benefits to be gained. Certainly, it is valuable to industry to have had this relief in respect of the precautions that they have had to take in the past. For the most dangerous dusts, experiments are being carried out to see how explosions in plant may be safely relieved and the plant isolated by means of rotary valves[20] (Fig.14).

Many fires in industry are caused by hot oils under pressure leaking onto the insulation surrounding pipes. In fact, this was placed as one of the highest causes of fire in the chemical and petrochemical industries. In the electricity generating industry alone, it has been estimated that in the United Kingdom these fires result in a generator being continually out of service. Experiments have been carried out[21] to identify oil and lagging combinations which are particularly prone to self-heating and as a result, a simple test has been developed which it is hoped will lead to a reduction in these fires.

SPECIAL INVESTIGATIONS

The repayment work carried out for industry is of particular importance to the Station and includes large fire-resistance tests on structures; tests on materials for combustibility and surface spread of flame; tests of fire detection and extinguishing equipment; and those for the explosibility of dusts. It is important for the Station to give as prompt a service as possible in this field in order that new innovations in industry can be evaluated as soon as possible. The current volume of test work amounts to about £40 000 a year and in addition to carrying out tests to current standards, the standards themselves have to be revised and new ones evolved.

Some materials have to be evaluated where no standard exists. The use of plastics in plumbing or on facades of buildings (Fig 15) are examples and large-scale tests had to be carried out on the first samples. It is hoped that the information gained from these tests will enable valid laboratory tests to be devised, thus reducing the cost and effort in subsequent tests.

Sometimes, it is possible to see how improvements in design can be made by carrying out a connected series of fire-resistance tests on materials.

For example, in recent years, the Station has been interested in the performance of laminated timber structures and a series of tests was carried out on columns with different species of timber and different types of glue[22]. As a result it has been found that an improvement in fire- resistance rating of up to 40 per cent can be obtained by judiciously choosing the species of timber and the type of glue used in making columns. Put the other way round, this means that by making a suitable choice it is possible to design structures more economically without sacrificing safety and as wood is an important material which the United Kingdom has to import, this is quite significant.

The Station plays an active part in the international field in the development of tests which involves its staff attending meetings and working parties in other countries, usually in Europe and Scandinavia.

LOOKING TOWARDS THE FUTURE

As has been pointed out, much requires to be known about the attitude of the public to fire and how to influence them in preventing outbreaks. Most of the fires at present are caused by carelessness or inadvertance and the study of public behaviour must be important in the future.

Fire protection ought to be studied as a system instead of as a series of isolated events such as, ignition, detection, spread, behaviour of structures, fire-fighting, etc. While it is essential to know about all of these individual facets, it must be remembered that they act together and therefore react on each other. Very little attention seems to have been given to studying the whole system. We, in the United Kingdom, are considering the interplay of structural fire precautions and fire-fighting, but this is only a beginning.

The studies we all carry out on fire research stop short at extinguishing the fire, whereas the end-product is to get the plant which has been involved back into production again. The present situation is analogous to an orthopaedic hospital setting broken legs in plaster but giving no thought to physiotherapy.

Of course, getting an industrial concern back into production is a highly specialized job, calling for co-operation with the industry itself. Alternative storage must be found, buildings have to be repaired, or even rebuilt, new machine tools provided or the old ones reinstated, all add up to a complex undertaking which could be pre-planned and programmed before a fire occurs and is much better organized in advance than in the massive dislocation following a fire. Firms should be encouraged to prepare critical path diagrams for this kind of operation - indeed one could pre-plan the fire-fighting for various parts of a factory and store this on a computer, always with the understanding that the plan might have to be varied during the actual fire. If the programme could not be followed exactly, it would at least, prevent some gross mistakes being made.

It is also necessary to make an assessment of the vulnerability of plants. Some areas are vital and must be protected at all costs but others are less important. Nature takes great care to protect the vital organs in our bodies and this kind of hazard assessment should be carried out in industry so that the amount of money spent on fire protection could be deployed to the best advantage. Such an assessment would be based on the chance of a serious fire developing in certain areas of the plant in relation to the value of that area to the production capacity of the factory.

These assessments will be thrown into sharp focus in the near future, because we shall be concerned more with automation, and probably with automatic factories, and the cost of the fire protection which will have to be built into the plant will be seen in relation to the normal process controls.

The evaluation of cost/benefit is likely to become a more dominant factor throughout fire protection activities and perhaps in the next ten years we shall have better data on which to make decisions. This seems to me to be a welcome change because I am sure that too little attention has been paid to fire protection in the past and this will be shown by a cost-benefit approach. Certainly it cannot be less effective than current fire protection which does not seem geared to the hazards of modern society.

ACKNOWLEDGMENT

The paper is Crown Copyright, ~~published~~ reproduced by permission of the Controller, H.M. Stationery Office.

REFERENCES

(1) BUTCHER, E. G., LANGDON-THOMAS, G. J. and BEDFORD, G. K. Fire and car-park buildings. Fire Note No. 10. (To be published by H.M. Stationery Office).

(2) PALMER, K. N. and ROGOWSKI, Z. W. The use of flame arresters in enclosed equipment in propane-air mixtures. (To be published in the Institution of Chemical Engineers Proceedings of the Symposium on Chemical Process Hazards III).

(3) DUNN, JENNIFER, E. and FRY, J. F. Brigade attendance times at fires in buildings. (United Kingdom 1963). Fire Research Technical Paper No. 19 London, 1968. H.M. Stationery Office.

(4) HOGG, JANE, M. The siting of fire stations. (To be published in Operational Research Quarterly).

(5) FRY, J. F. and SAINT, CICELY, E. General knowledge of fire protection among householders in London. Joint Fire Research Organization Fire Research Note 612/1966.

(6) CHAMBERS, E. D. Behaviour when faced with fat pan fires. Joint Fire Research Organization Fire Research Note 654/1967.

(7) CHAMBERS, E. D. The statistical background to the Exeter chip pan safety campaign. Joint Fire Research Organization Fire Research Note 679/1967.

(8) THOMAS, P. H., HESELDEN, A.J.M. and LAW, MARGARET. Fully-developed compartment fires - two kinds of behaviour. Fire Research Technical Paper No. 18. London, 1967. H.M. Stationery Office.

(9) The behaviour of structural steel in fires. Ministry of Technology and Fire Offices' Committee Joint Fire Research Organization Symposium No. 2. London, 1968. H.M. Stationery Office.

(10) THOMAS, P. H., BALDWIN, R. and THEOBALD, C. R. Some model-scale experiments with multiple fires. Joint Fire Research Organization Fire Research Note 700/1968.

(11) BUTCHER, E. G., FARDELL, P. J. and CLARKE, J. J. Pressurization as a means of controlling the movement of smoke and toxic gases on escape routes. Joint Fire Research Organization Fire Research Note 704/1968.

(12) DUNN, JENNIFER, E. and FRY, J. F. Fires fought with five or more jets. Fire Research Technical Paper No. 16. London, 1966. H.M. Stationery Office.

(13) LAWSON, D. I. Fire detectors using laser beams. Fire Prot.(Rev.), 1968, 31 (333).

(14) LAWSON, D. I. and McGUIRE, J. H. A fire detector for those smoky jobs. Fire, 1956, 48 (611) 597.

(15) RASBASH, D. J. Notes for the specification of high-expansion foam liquid. Joint Fire Research Organization Fire Research Note 706/1968.

(16) RASBASH, D. J., LANGFORD, B. and STARK, G.W.V. Production of high expansion foam for fire-fighting, using a jet engine. Fire (Internat.), 1965, 1 (9) 61-76.

(17) FITTES, D. W. and NASH, P. Research on 'light water' in the United Kingdom. (To be published).

(18) THORNE, P. F. Some recent research on dry powders. (To be published).

(19) RAFTERY, MONICA, M. Explosibility tests for industrial dusts. Fire Research Technical Paper No. 21. London, 1968. H.M. Stationery Office.

(20) PALMER, K. N. Dust explosions in industrial plant. Engineer, Lond., 1967, 224 (5837) 760-1.

(21) BOWES, P. C. and LANGFORD, B. Spontaneous ignition of oil-soaked lagging. Chem. Process Engng, 1968, 49 (5) 108-16.

(22) MALHOTRA, H. L. and ROGOWSKI, B. F. Fire-resistance of laminated timber columns. Joint Fire Research Organization Fire Research Note 671/1967.

FIG. 1. FIRE IN CAR PARK DID NOT SPREAD BEYOND FIRST CAR IGNITED

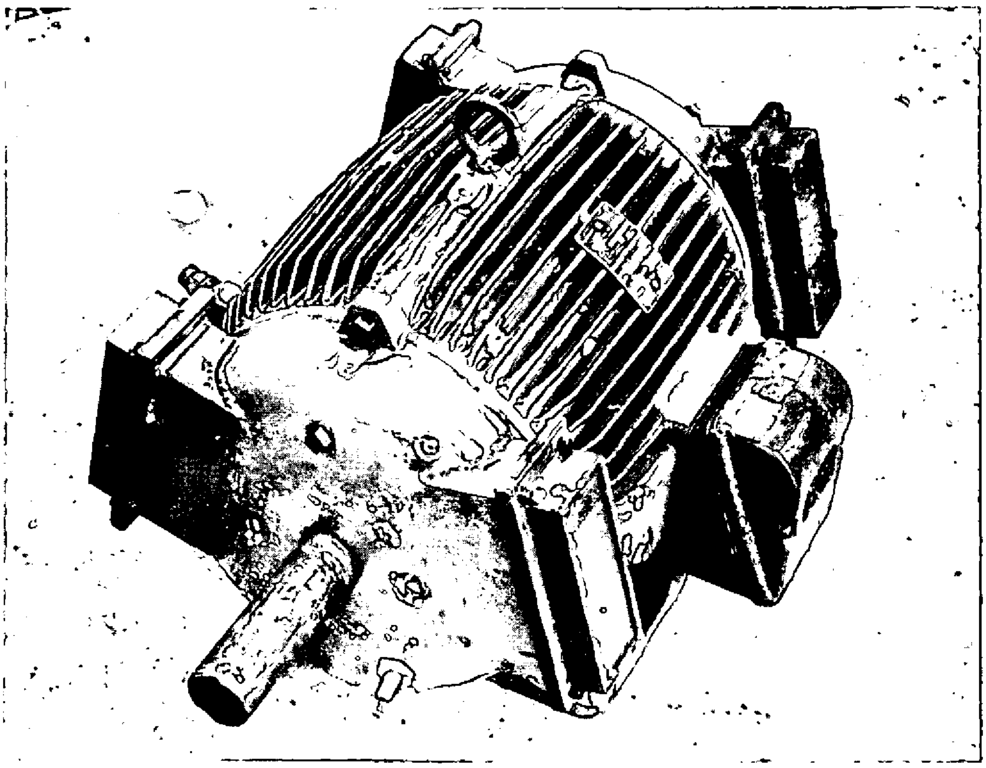


FIG. 2. MOTOR FOR USE IN FLAMMABLE ATMOSPHERES (Note flame arresters on end plates)

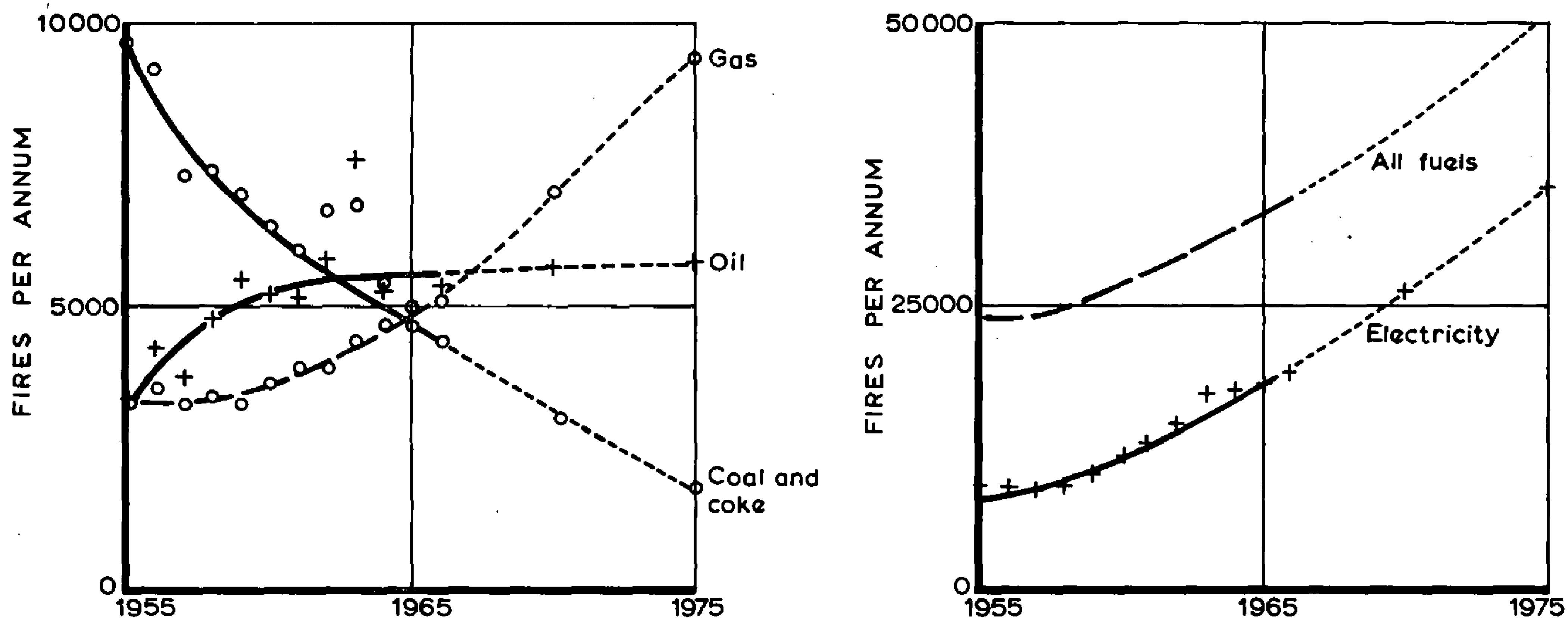


FIG.3. FORECAST OF FIRES IN BUILDINGS DUE TO FUELS BASED ON FUTURE FUEL POLICY AND HAZARD OF FUEL

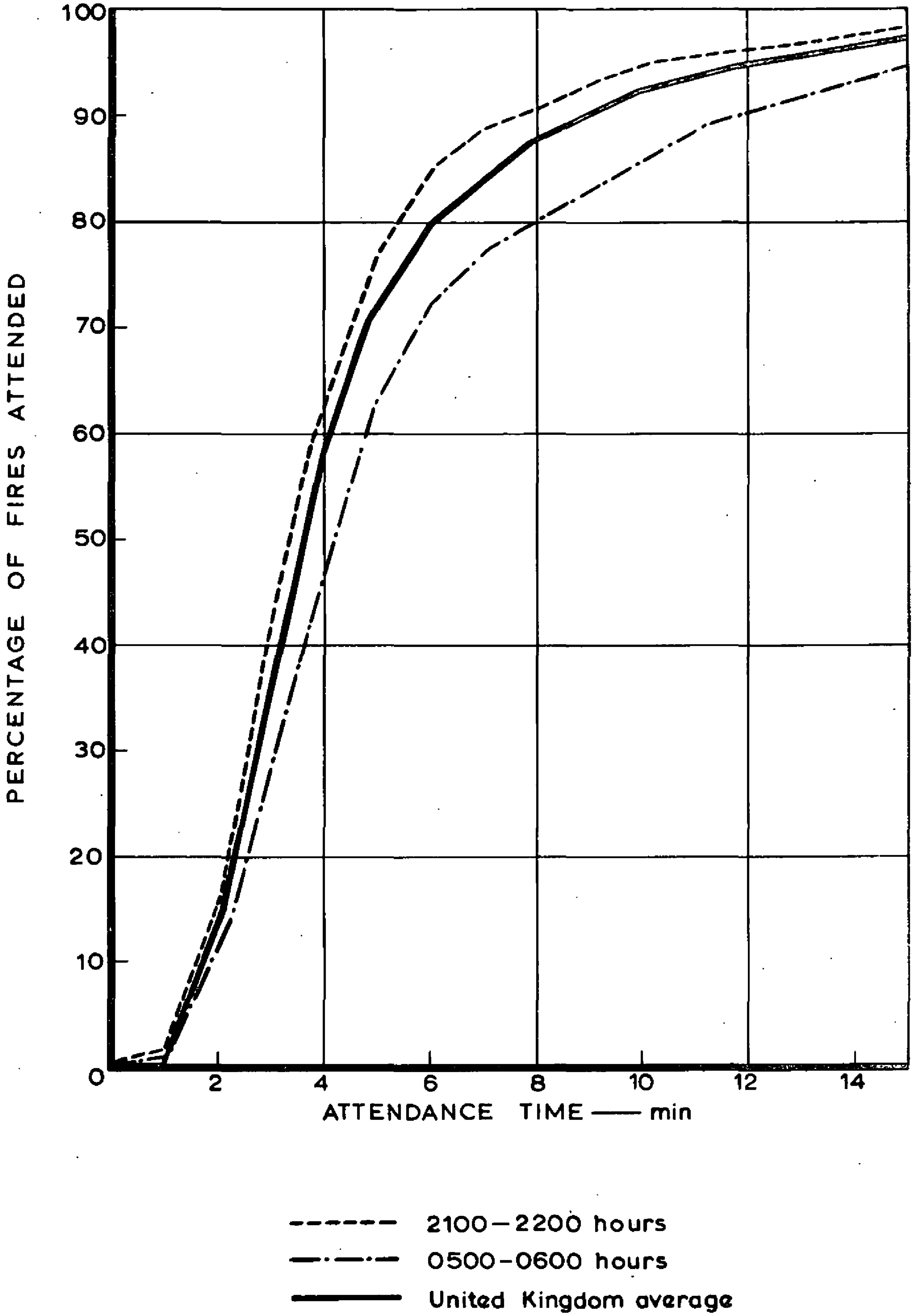


FIG. 4. VARIATION OF ATTENDANCE TIME WITH TIME OF DAY

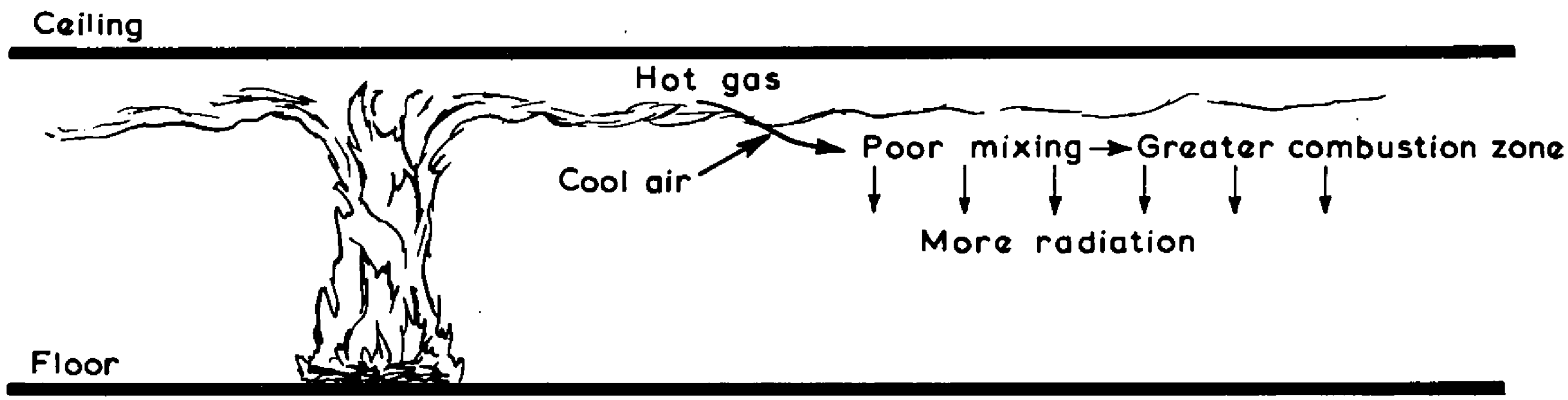


FIG. 5(a). WHY CEILINGS AID FIRE SPREAD EVEN IF NON-COMBUSTIBLE

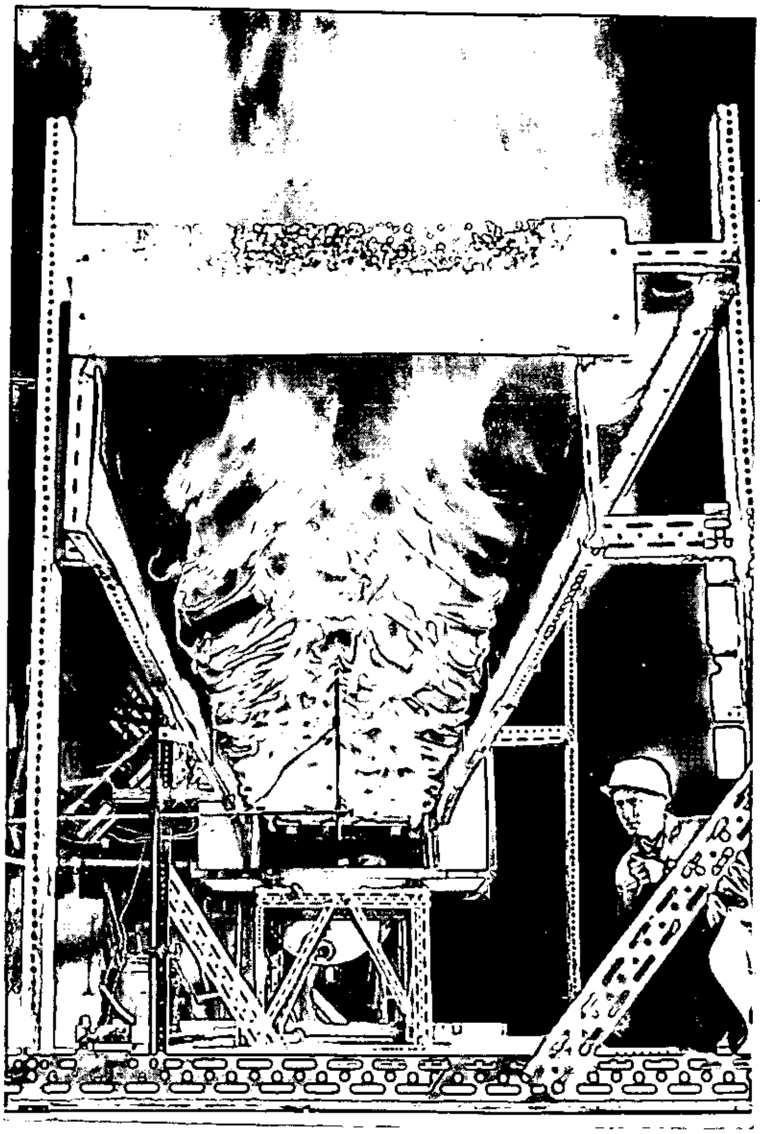
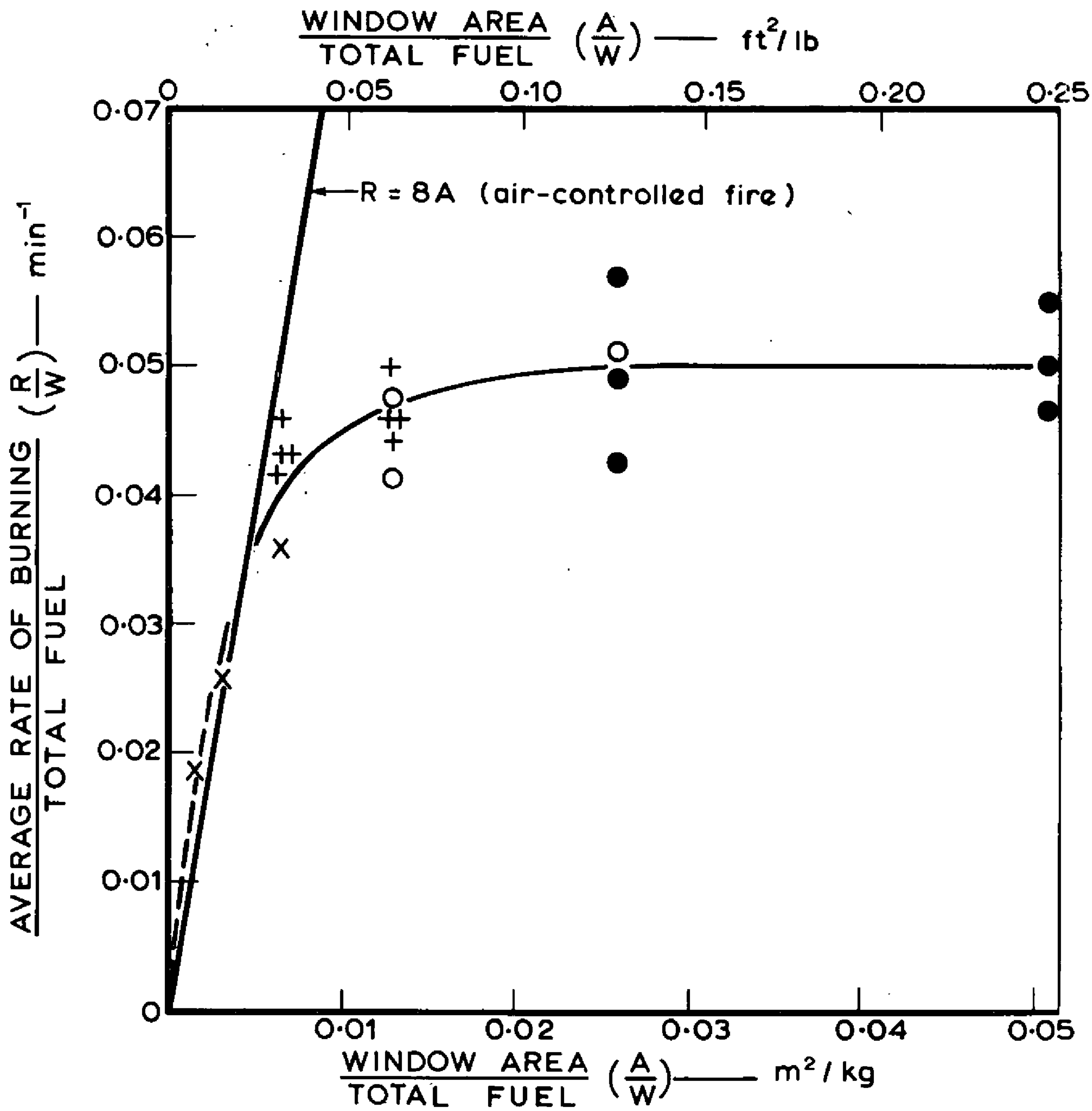
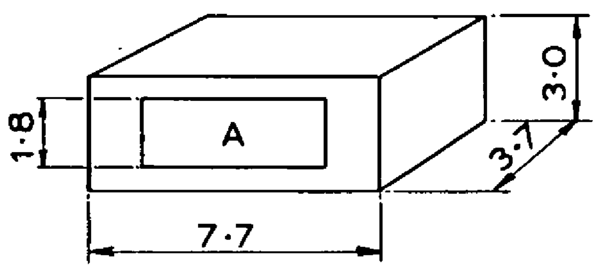


FIG. 5(b) FLAMES LENGTHENING
UNDER CEILING

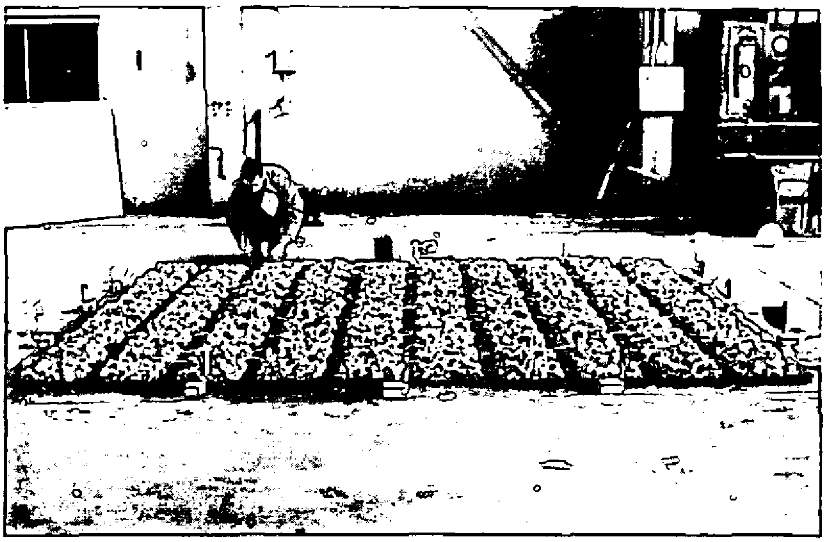


Symbol	Fire load density	
	kg/m²	lb/ft²
X	60	12
+	30	6
O	15	3
●	7·5	1·5

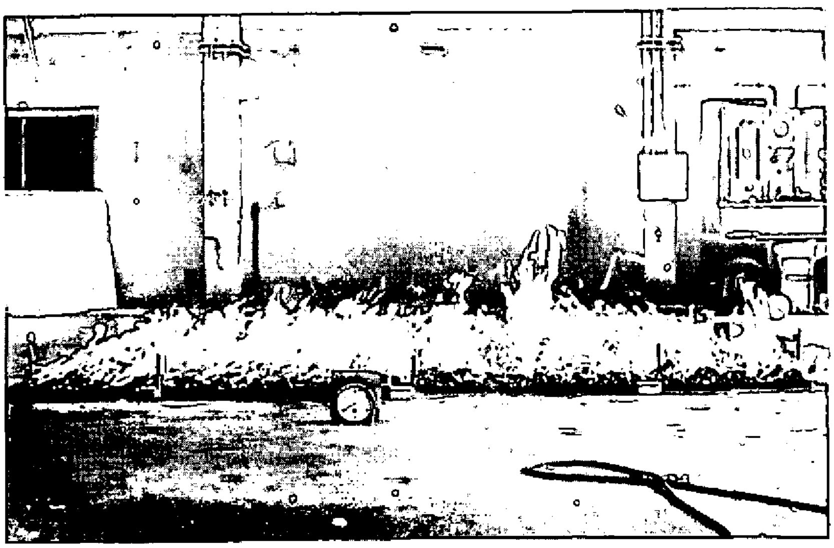


Dimensions in metres

FIG. 6. NORMALIZED BURNING RATES OF FIRES IN COMPARTMENTS



(a) Before ignition



(b) With flames merging

FIG. 7. MULTIPLE FIRE EXPERIMENTS
(10 x 10 1-ft square heaps with 3-in gaps)

1/6846 Publication

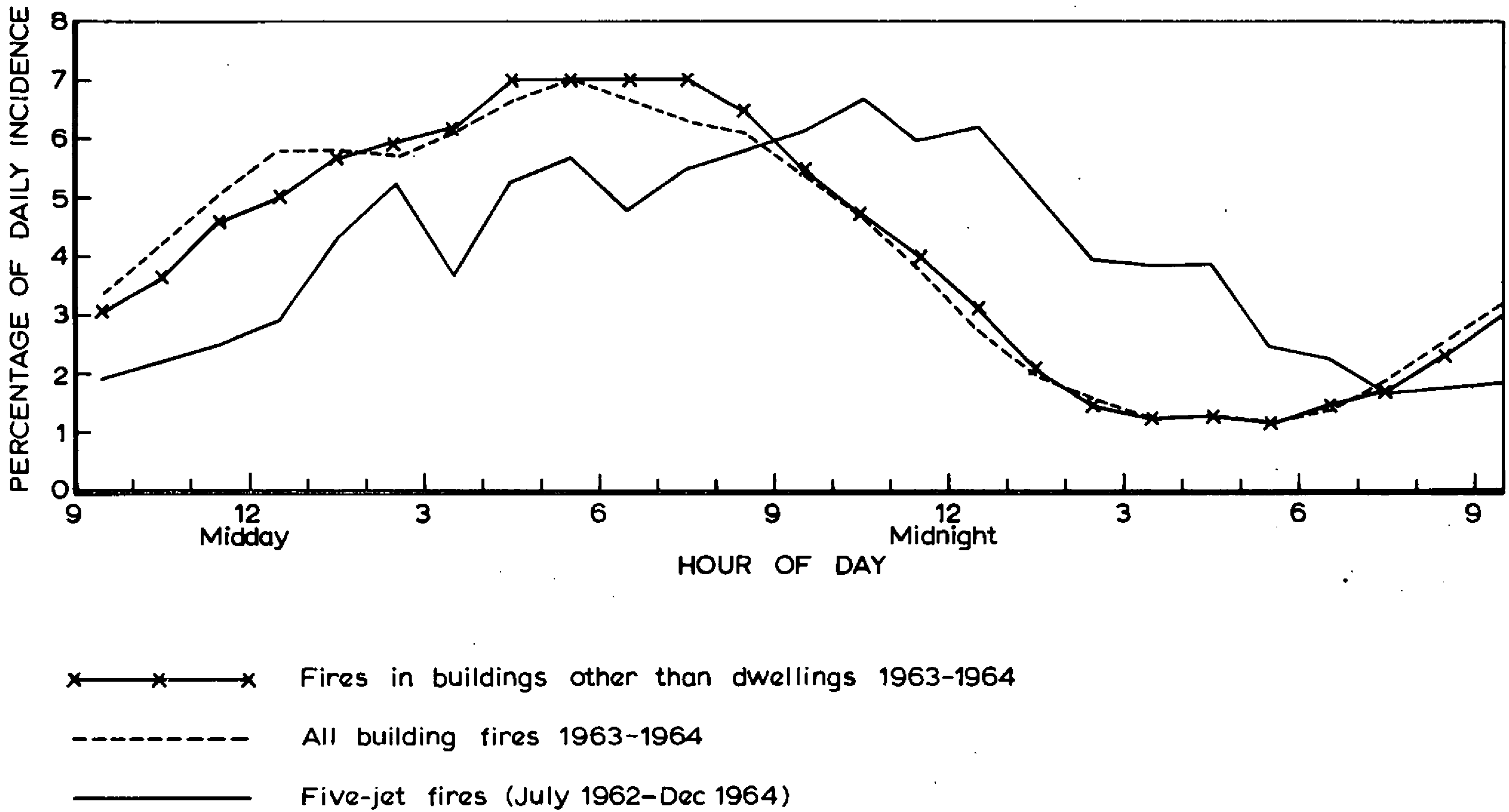


FIG.8. TIME OF DISCOVERY OF FIVE-JET FIRES (JULY 1962-DEC 1964)

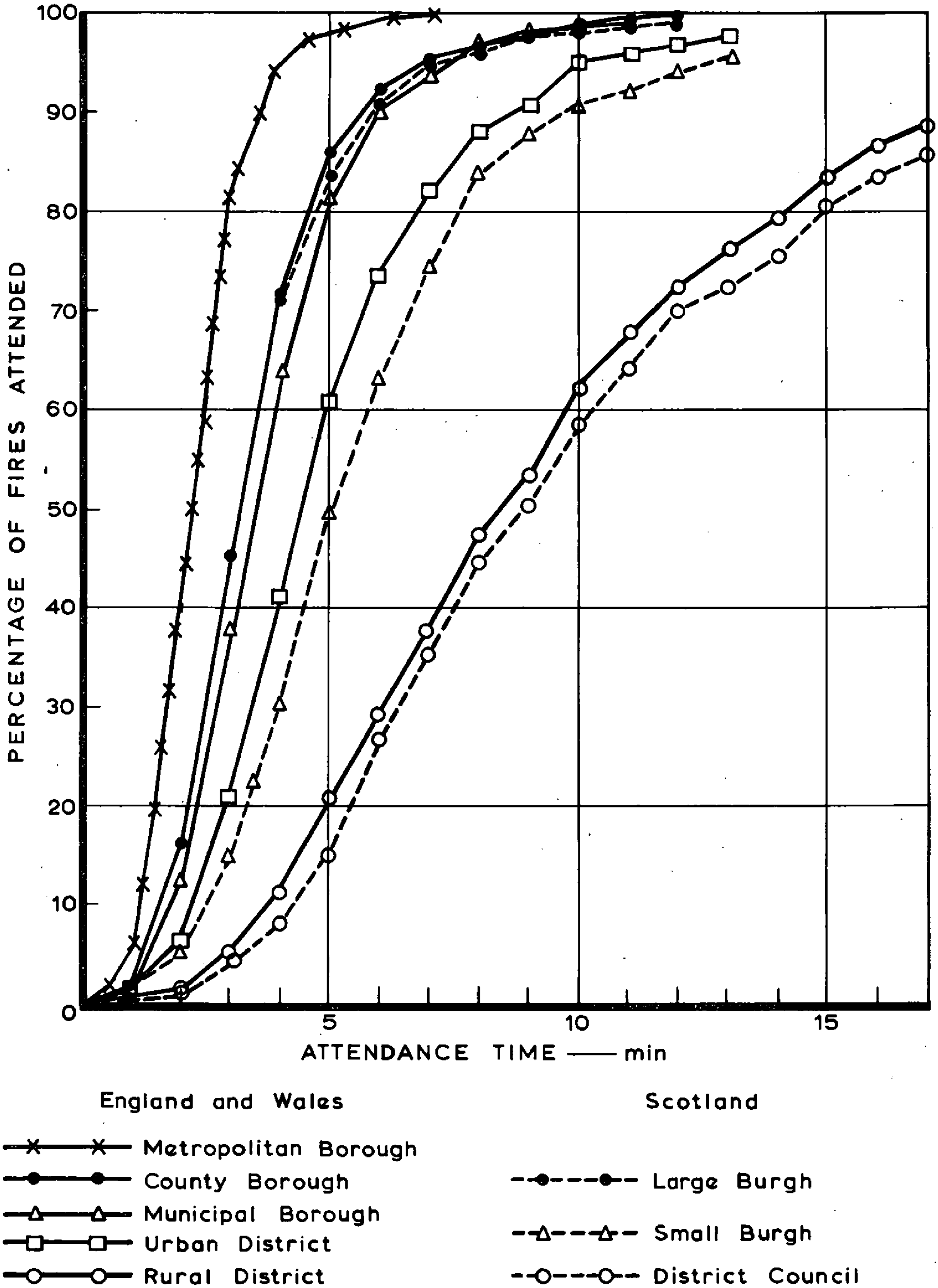


FIG. 9. VARIATION OF ATTENDANCE TIME WITH AREA IN WHICH FIRES OCCURRED

1/7772 TECH. PAPER No. 19

FIG. 10 PRELIMINARY EXPERIMENTS WITH
LASER BEAM FIRE DETECTOR

FIG. 11 MEASURING THE TEMPERATURE OF SMOKE ISSUING FROM WINDOWS

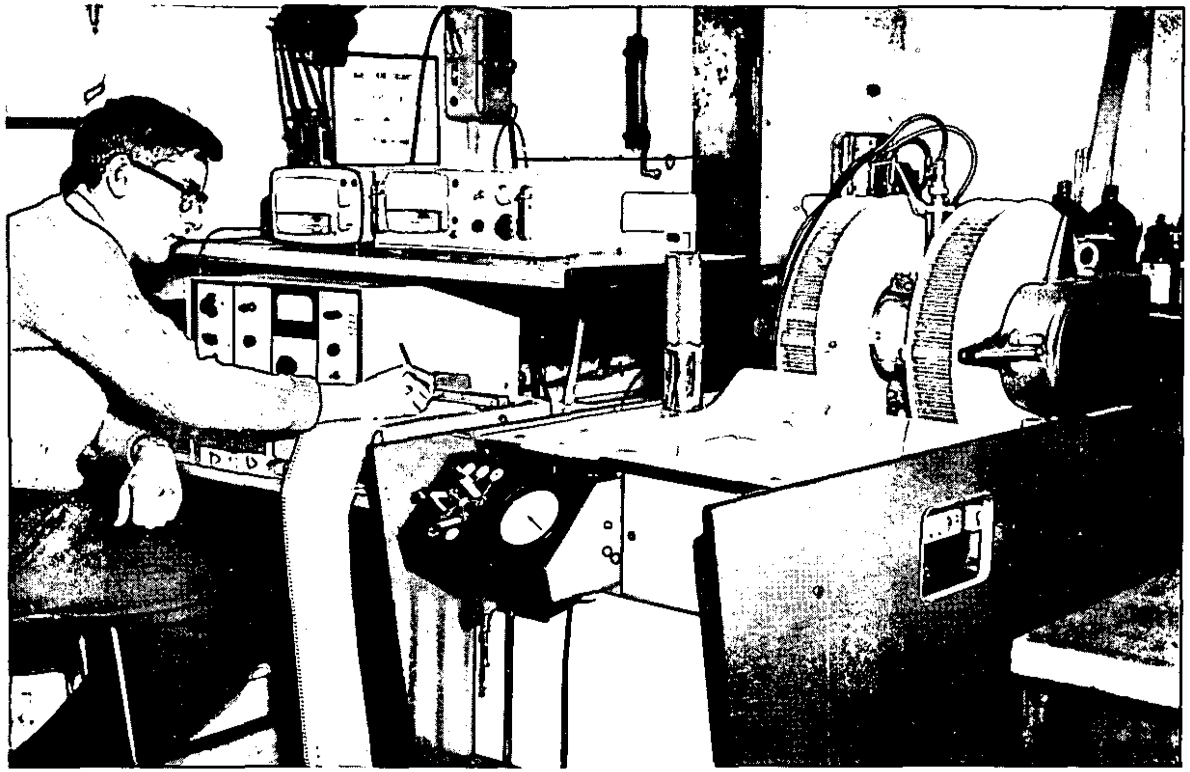


FIG. 12 EXAMINATION OF DECOMPOSITION PRODUCTS FROM PLASTICS WITH MASS SPECTROMETER

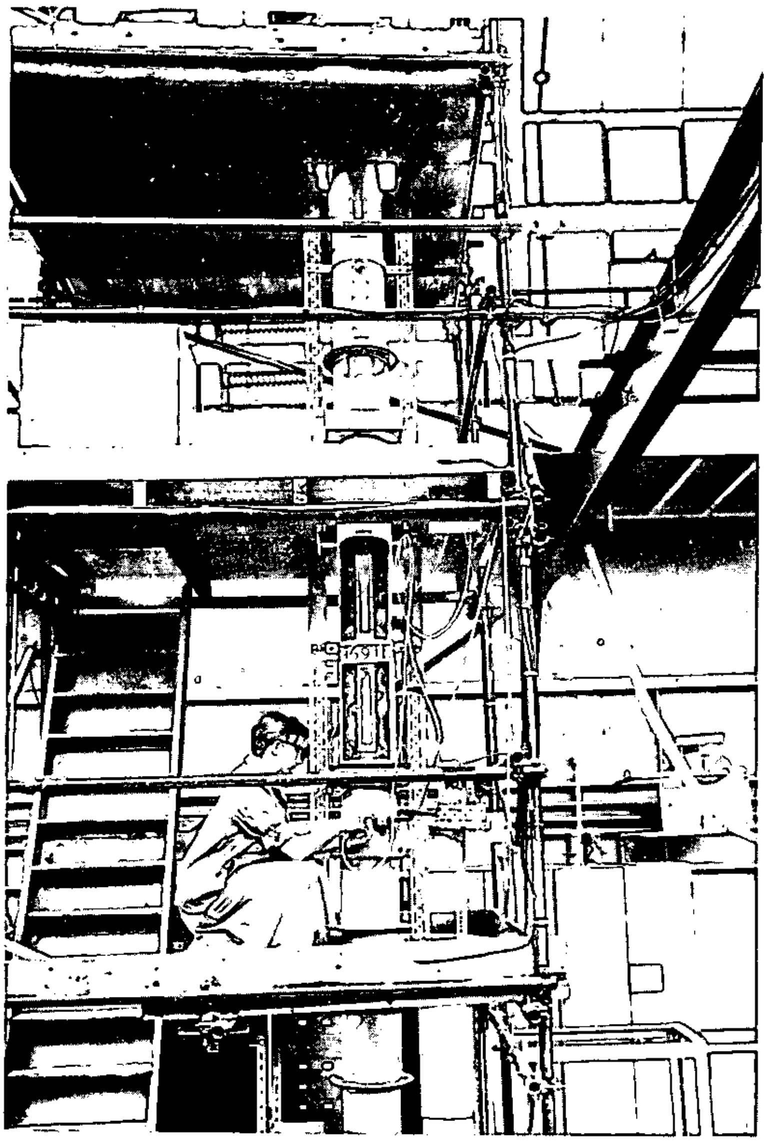


FIG. 13 APPARATUS FOR MEASURING DUST EXPLOSION HAZARD. A CLOUD OF DUST FALLING IN THE VERTICAL TUBE IS IGNITED

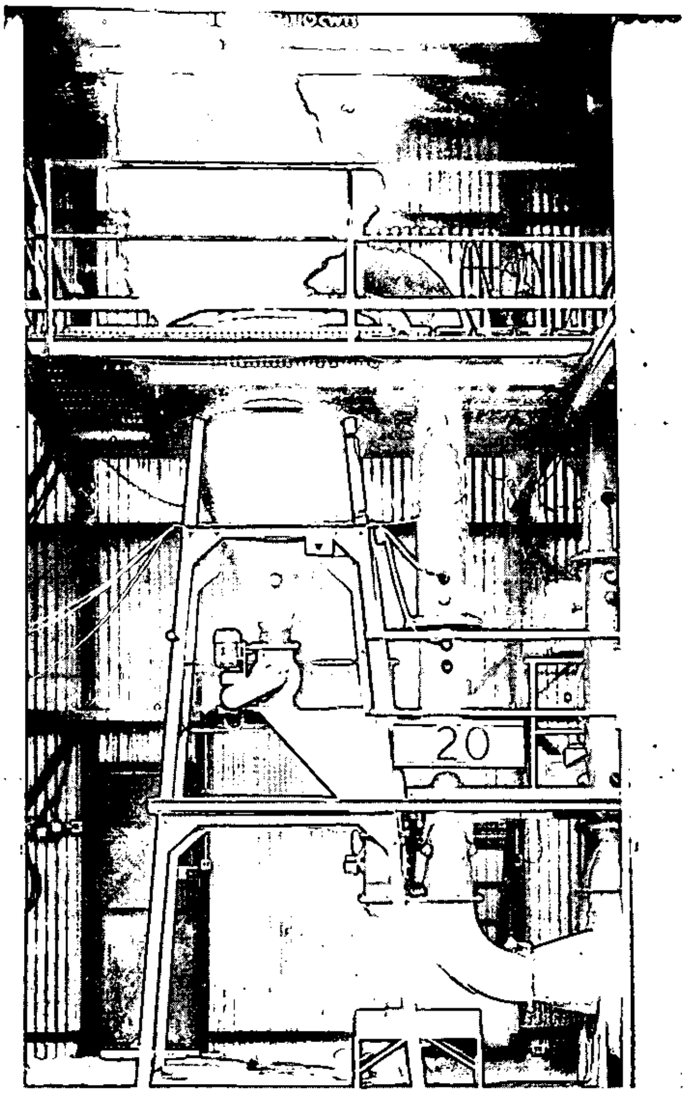


FIG. 14 CORK DUST EXPLOSION
IN CYCLONE PLANT

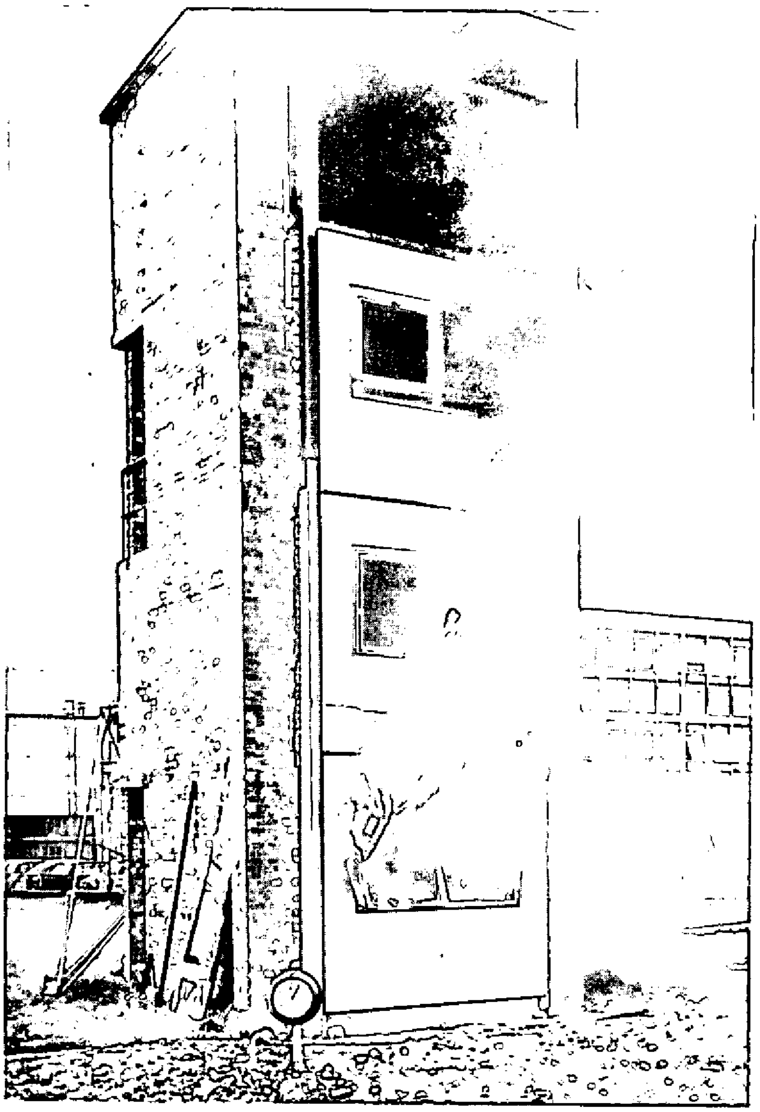


FIG. 15 FIRE TEST ON BUILDING
WITH PLASTICS PANELS