DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

AND

FIRE OFFICES' COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

FIRE RESEARCH NOTE

NO. 539

SYMPOSIUM ON THE USE OF INERT GAS AND HIGH EXPANSION FOAM FOR THE CONTROL OF FIRES IN LARGE SPACES

HELD AT JOINT FIRE RESEARCH ORGANIZATION - SEPTEMBER 1963

Fire Research Station.
Boreham Wood.
Herts.
('phone ELStree 1341)

February, 1964.

F.R. Note No. 539

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Introduction

A possible way of fighting fires is to fill the whole space in which the fire is burning with a suitable inert gas or foam. This method has potential application in certain particular fires where either (a) conventional methods cannot be easily applied e.g. deap seated fires in holds of ships (b) it is desirable to obtain control of the fire more quickly or with less water damage than is obtained by conventional means e.g. large fires in buildings. There have been a number of developments in recent years aimed at providing inert gas and foam for these purposes, of the requisite properties and at the requisite flow rates. Some of these developments were discussed at a symposium organized by the Joint Fire Research Organization at the Fire Research Station on September 26th and 27th 1963.

The symposium was attended by 73 representatives from interested bodies including the Fire Brigades, Government Departments and Industry.

In addition to the presentation of a number of papers at this symposium, there were discussions and demonstrations with the Joint Fire Research Organizations experimental jet engine appliance.

An account of the proceedings of this symposium is given in this note which has been subdivided as follows.

Part I Summary of papers read.

Part II Account of experimental demonstrations.

Part III Summary of the points raised in discussion.

Appendix I Programme of the symposium.

Appendix II List of participants.

Appendix III Photographs taken during the symposium.

PART I. SUMMARY OF PAPERS READ AT THE SYMPOSIUM

THE PRODUCTION AND USE OF FIRE FIGHTING MEDIA BASED ON JET ENGINES

by

D. J. Rasbash, A.R.C.S., Ph.D., M.I.Chem.E.

(Joint Fire Research Organization)

The processes whereby the exhaust of a jet engine may be converted into fire-fighting media of different types were described. These processes include the removal of oxygen from the air by combustion, the cooling of the hot gas with and without the evaporation of water spray, the entrainment of air into a high velocity jet, the atomisation of a large quantity of water into a high velocity jet and the manufacture of foam by passing the gas through a net onto which a foam solution is sprayed. The gases and foams that may be produced by these means may be used to fill a building in which there is a fire. Ideally for this purpose, a medium would be required which would fill the building rapidly, extinguish all fires and remove smoke rapidly, and which would also be transparent, comfortable to work in and respirable. Ideally the medium should also be cheap, easy and safe to produce on the fire ground and should cause no damage to the building or its contents or be a nuisance to the public. Although none of the media which may be produced with jet engines, fulfil all these requirements, a number fulfil most of them. In practice an appliance will need to produce either a single medium which is particularly useful for a special type of job, or a small number of media, say three to four, which would allow the appliance to be more useful generally.

An appliance similar to that tested by the Joint Fire Research Organization will produce at least three fire-fighting media which could be fairly widely useful. These are - a comparatively cool transparent respirable gas which reduces flame but does not extinguish it; a high expansion foam which will put out flaming combustion and also under some conditions smouldering combustion, and a hot gas which will rapidly extinguish flaming combustion. Ways of using these media under practical fire-fighting conditions will be discussed.

EXPERIENCE GAINED IN THE OPERATION OF THE J.F.R.O. INERT GAS AND FOAM GENERATOR

by

G. W. V. Stark, B.Sc., A.R.I.C.

Joint Fire Research Organization

The J.F.R.O. inert gas generator, built by the N.G.T.E., comprises a Viper Jet Engine followed by a reheat section, the hot gases from which are cooled and humidified by water spray. It has been used for a series of tests to assess its potential for fire-fighting in large buildings and basements.

Three gases have been used in these tests, namely a gas that can extinguish flames and reduce burning to a very low rate, a gas that can be used for smoke clearing and some control of fires and their rate of burning, and a gas that can be used for a production of high expansion foam. The tests were made in the Models Laboratory at the Fire Research Station, and in the basement of a disused building.

The first gas, produced by burning fuel in reheat at 1-2 times the rate of burning in the jet engine, contained 7-10 per cent oxygen and was delivered at up to 45000 ft^3/min and 100-120°C. It was too hot to bear for men wearing standard fire fighting clothing and breathing apparatus, and because of its high moisture content, 45 per cent, gave misty atmospheres on cooling. The second gas, produced by running the appliance without reheat, and entraining about 30 per cent air into the gas, was a clear, cool, gas containing about 15 per cent water vapour. The gas gave some control of burning but supported life as it contained 17 per cent oxygen. The rate of production, 36,000 ft^3/min, and its temperature allowed smoke clearing and men wearing standard clothing and breathing apparatus to enter and work. The third gas, produced by running the generator without reheat, was used to produce foam of high expansion, 1000 to 1, at about 15,000 ft^3/min. This foam extinguished fires of solid and liquid fuel, including alcohol. The foam was cool enough (40°C) to permit firemen to work in it. It caused little water damage because of the small amount of water used, i.e. 200 gal/min of foam solution containing 1 per cent active detergent.

The experiments showed that the gas could be delivered through 30 in dia. flexible ducting, at least 50 ft long. A wire helix supported neoprene coated terylene duct gave the best performance of those tested, and withstood temperatures exceeding 150°C. To make the foam a terylene or nylon mesh bag was attached to the end of the duct, and was sprayed on the inside with detergent solution. The bag was also used to diffuse the gases and stabilise the ducting and may also be used to provide additional cooling of the gas stream by spraying with water instead of foam solution.

The inert gas generator has been in use since 1960. In that time repairs have been necessary, but they could in the main have been avoided by supplying the engine with clean, dry fuel, by proper maintenance of the controls and starter batteries and by regular servicing of the turbo-jet and its auxilliary gear. Entry of water into the turbine occurred because of the horizontal layout of the system.

The design of future applainces could well be such as to provide only a few specific gases and foam, by the operation of a simple set of controls. Safety devices to cut out the engine or reheat on ignition failure and to give warning of excess temperatures of the gas stream should be incorporated. The appliance should have a fall from air entry to gas outlet to prevent water entering the turbine.

USE OF THE FOAM PLUG PROCESS FOR FIGHTING MINE FIRES

by

D. G. Wilde, B.Sc.

Ministry of Power, Safety in Mines Research Establishment

When a large fire occurs in a ventilated mine roadway, it can only be attacked from the upwind side and even then, because of heat from the fire or the danger of falls of ground, direct manual control of the fire may be impossible. Once this stage is reached the affected portion of the mine usually has to be sealed off. The foam plug method of firefighting offers a means of control which may be used as an alternative to sealing off in some cases.

The method depends on the continuous formation of a mass of high expansion air/water foam by spraying a net stretched across a ventilated mine roadway with a dilute solution of a foaming agent. Films of solution, formed on the pores of the net, are distended and subsequently detached in the form of bubbles by the air current. Foam produced by the rapid accumulation of bubbles is propelled along the roadway by the ventilation pressure. Foam plugs can move over rough and dusty surfaces and surmount large obstructions in mine roadways.

Satisfactory foam plugs can be generated over hundreds of yards of level mine roadways, but the effective range of operation is controlled by factors such as the gradient and direction of slope of roadways and loss of water from the foam plug rather than by the distance between the net and the fire.

Spraying nozzles and nets suitable for the formation of foam plugs have been specified and the limits of rate of supply and pressure of water and speed of the ventilating air necessary for successful foaming are known. Many commercial foaming agents have been examined and by choice of suitable agents it is possible to make foam plugs in mine roadways from water containing up to 2,700 p.p.m. of hardness.

Control of fire by foam plugs is achieved by a combination of the cooling effect of the water in the foam and the dilution of atmospheric oxygen resulting from the conversion of water into water vapour. The balance between these mechanisms depends upon the type and stage of the fire. Foam plugs have extinguished flaming combustion in experimental fires burning up to 2½ tons of wood, when the fires were either in stacks which filled the cross-section of an underground roadway or were in a timber lining on a 60 ft stretch of the roadway walls. The method is suitable only for open, flaming combustion and needs to be followed up by firefighters equipped with hoses.

The method has been used against a serious and well-developed accidental fire in a mine in the U.S.A. Although it was applied in unsuitable circumstances, it was partially successful and prevented the loss of a large part, if not the whole of the mine concerned.

USE OF INERT GAS FOR CONTROL OF FIRES IN SHIPS

by

F. Rushbrook M.I.F.E., A.I.Mar.E.
Firemaster, Edinburgh

Although in 1962 there was a welcome reduction in the total tonnage of ships lost through fire - 13 vessels of 60,319 gross tons against 20 vessels of 127,300 gross tons - the position is far from satisfactory. Already this year up to the end of June, 13 vessels have been lost through fire whilst 218 vessels have suffered from fires which have caused damage to ship and/or cargo.

A study of the 1962 Annual Report of The Liverpool Underwriters' Association reveals that fires in holds accounted for 188 out of a total of 370. It is further revealed that almost three times as many fires took place in port against those occurring at sea. These facts go to show that it is a worth while exercise for fire brigades to pay attention to methods which can control fires in holds whilst minimising the damage both to cargo and to the fabric of the ship.

Unfortunately it is quite obvious that fire brigades are not taking advantage of new equipment and techniques, but tend rather to fight ship fires in the manner of their forefathers. In order to appreciate why this should be so it is necessary to understand something of the machinery of Local Government finance. Before a Chief Fire Officer or Firemaster can purchase an expensive piece of equipment he has to convince his Authority that it is (a) going to justify its purchase price by reasonable incidence of use, (b) that the equipment is of such design that it has been proved to be more effective than conventional apparatus available at a lower cost.

Acting as "Devil's Advocate", I can understand the feeling of some elected representatives wondering whether the Local Authority ratepayers should pay for what appears to be equipment designed specifically for use on board ships - many of which are in foreign ownership or at any rate are not necessarily registered in the particular port area. Under the Rating Valuation (Apportionment) Act, 1928, freight transport undertakings are subject to a rating relief amounting to half the net value. Some Rating Authorities also grant special relief which is peculiar to that area - usually under some Local Act, so that there is a degree of reluctance amongst sections of public administration to spend what might appear to be an unnecessarily large sum for specialised fire protection. Whilst I would not support this type of thought I do wonder if highly specialised equipment such as mobile inert-gas generators could not be purchased by a consortium of Local Authority Fire Brigades and maintained at strategic points ready to be sent to any port when the need arises. After all the type of fire at which such equipment can be of value is not one where all out speed of attack is required. An availability of up to two hours would be quite acceptable during which time the ship's hold can be kept closely battened down and the built-in equipment can keep the fire in check.

There are two ways by which inert-gas for fire-fighting purposes can be produced. Briefly the first system employs an oil-fired furnace surrounded by a water jacket and the products of combustion are cooled and then pumped to the point at which they are required. The second method employs the exhaust gases from a Gas Turbine engine which is fitted with an after burner.

I will confine my short talk to a brief illustrated description of the two systems and trust that during the discussion which follows some interesting points will be raised.

ANSTY

DESIGN OF A JET ENGINE INERT GAS AND FOAM GENERATOR.

Speaker: B. H. Slatter, B.Sc., A.M.I.Mech.E., A.F.R.Ae.S.

(Bristol Siddeley Engines Ansty)

During the past three years, tests have been made by the Joint Fire Research Organization using an experimental inert gas producing unit which was built by the National Gas Turbine Establishment and which employs a Viper jet engine. The tests have shown that this type of equipment has every promise of becoming a powerful fire fighting appliance for dealing with certain types of fire.

The next step is to produce an appliance suitable for use by Fire Brigades and embodying the results of the lessons learnt from the prototype trials. Bristol Siddeley have decided to design and manufacture a fire fighting vehicle along these lines and the lecture describes this project which is based on the use of a Viper 8 jet engine.

The machine is capable of producing inert gas or foam quickly on arrival at a fire and is reasonably straightforward to operate. While safeguards must be provided against incorrect operation, the need to avoid complexities which could lead to high cost and difficult servicing problems have been borne in mind. Apart from the actual inert gas and foam generating equipment, the vehicle carried supplies of fuel for the jet engine and foam agent to provide a reasonable period of operation before additional supplies must be brought to the scene.

First the functional requirements are given upon which the design is based. The machine is designed to produce about 50,000 cu.ft/minute of inert gas having an oxygen content of less than 10 per cent and to provide, when necessary, a sufficiently cooled efflux to enable firemen to enter a building into which the gas is being fed. In addition, foam generating capability using inert gas is incorporated with ability to change from one type of operation to another rapidly without shutting down the jet engine.

The working of each part of the system from the jet engine to the delivery hose is briefly described and this leads to an explanation of the layout adopted and the choice of a suitable Dennis chassis. Illustrations of the vehicle and its equipment are included.

The lecture deals with the control of the various systems. The method of starting the Viper engine and means for controlling it while running are described, together with the operation of the reheat system downstream of the turbine. The manner in which the control for the engine, water system and by-pass and dilution air valves are brought to a convenient operating point is illustrated and instruments and safety devices which are incorporated are described.

Finally, the procedure to be adopted to bring the appliance into operation is dealt with and an indication is given of likely future progress with the project.

PART II. EXPERIMENTAL DEMONSTRATIONS

Foam Test

Object To demonstrate the ability of the generator to produce high expansion foam, and the extinguishing power of this foam.

In this test foam was applied to fires of scrap wood, acetone, alcohol and petrol. The wood fire was a conical heap about 6 ft diameter and 3 ft high built up with timber of varying size, but largely 1 in square. The liquid fires were in trays of 2 ft, 4 ft and 3 ft diameter respectively. The position of the fires and the foam bag is shown in Fig 1. They were placed in an area 40 ft x 50 ft at one end of the Models Laboratory, bounded by 3 walls and a 5 ft high tarpaulin screen erected across the Laboratory. Foam was generated by passing gas from the generator, composition oxygen 15 per cent, nitrogen 65 per cent, carbon dioxide 1.5 per cent and water vapour 18.5 per cent, produced at 80-90°C and 27000 ft^3/min through a bag of nylon mesh fabric sprayed on the inside with 170 gal/min of foam making solution containing 1 per cent of ammonium lauryl sulphate. Foam was made at a rate of about 11,000 ft^3/min at 40°C. Allowing for the reduction in volume of gas produced by this cooling, the foam was therefore produced at an efficiency of about 50 per cent. The gas contained in the foam had the composition oxygen 17 per cent, nitrogen 74 per cent, carbon dioxide 1.6 per cent and water vapour 7.4 per cent.

The extinction times for the fire, as judged by the absence of flames breaking through the surface of the foam for the liquid fires, and the absence of blue smoke breaking through the foam for the wood fire, are given in Table below:-

Extinction Times of Fires with Inert Gas Foam

Fire	Dia. ft.	Time, Secs.
Wood	5	60
Ethyl Alcohol	4	5
Acetone	2	3
Petrol	3	7

The liquid fires were extinguished soon after the advancing foam covered the tray containing the fuel. The wood fire was not extinguished until some time (about 30-40 seconds) after it had been completely covered by foam.

Photographs taken during the experiment are shewn in Appendix III.

Inert Gas Test

Object To demonstrate the ability of the generator to clear smoke from a large building in which fires are burning, and to modify the atmosphere in a way which would allow entry by fire fighting personnel.

In this test inert gas from the generator was passed into the Models Laboratory, an open compartment 130 ft x 50 ft x 40 ft high of about 250,000 ft^3 volume, through a 2 ft 6 in diameter steel duct. Three 3 ft diameter fires of gas oil at heights of 8, 12 and 16 ft and a wood crib fire at a height of 12 ft were lit about 5 min before introduction of the gas. A 6 ft diameter fire of paraffin and petrol on the floor was also ignited to produce rapid smoke logging of the building. The wood and gas oil fires were of sufficient fuel to burn for about 30 min, but the paraffin petrol fire contained enough fuel to burn for only 5 min or so.

Gas was introduced when the Models Laboratory was smoke logged except for 3-4 ft at floor level. Introduction of inert gas at about 110°C and 45,000 ft^3/min, and of composition oxygen 7 per cent, nitrogen 46 per cent, water vapour 44 per cent, carbon dioxide 3 per cent was seen to push black smoke out of the gaps between the asbestos sheet cladding of the building. As the test proceeded, the escaping black smoke was replaced more and more by white steam, and after 10-12 min injection the replacement was complete.

The Models Laboratory was entered at 12 min, when the temperature at the 6 ft level was about 75°C (170°F). The atmosphere was hot and felt moist, but was fairly clear, giving good visibility. All flames had been extinguished. The composition and temperature of the gas were charged after 15 min. injection by turning off the fuel to the reheat system and reducing the water supply to maintain an outlet temperature of 60-70°C. This cooler gas was injected at about 27,000 ft^3/min, and had the composition, oxygen 15 per cent, nitrogen 66 per cent, carbon dioxide 1.5 per cent, and water vapour 17.5 per cent. The cooling effect of this gas made the water vapour already present in the atmosphere condense to form mist. The mist cleared in about 8 minutes, so that visibility extended across the width of the Models Laboratory and visibility was good along the length of the Models Laboratory in a further minute. A party of visitors was conducted through the Laboratory at this stage when the three gas oil fires could be seen to be out, and there was no smoke visible from the wood fire. Injection of gas was stopped after 15 min., and the sliding roof of the Models Laboratory was opened to give an aperture of about 1,500 ft^2. The wood fire was then seen to be smouldering, but at first the fumes were white, consisting mainly of steam. The wood rekindled after about 10 min. and full burning was then established quickly.

Photographs taken during this experiment both inside and outside the building are shewn in Appendix III.

PART III. SUMMARY OF DISCUSSION PERIODS

Function of an appliance

The opinion was expressed that whatever appliance was developed for use with the fire brigades it should be able to do one job absolutely reliably; other jobs which it could do would then be regarded as extra benefits. There was some difference in the opinion as to what this specific task of the appliance might be. One possible task was to extinguish deep seated fires in holds of ships and basements without the necessity for the firemen entering the premises; it was thought by some speakers this would be acceptable even if it took several days to extinguish fires in this way. Other possible tasks mentioned was the use of high expansion foam to prevent fire damage to stored goods etc. and the use of inert gas and foam to extinguish fires in ships engine rooms. The work with the J.F.R.O. appliance had been carried out with a view to its application for large fires in buildings generally, but there were undoubtedly specific types of fire where appliances with smaller output could find application.

Ideal gas for inerting

If complete extinction was required then the ideal gas was one which was cool and contained less than 2 per cent oxygen. For this purpose a low temperature gas (e.g. about 30°C) is likely to be more efficient than a high temperature gas (e.g. about 100°C) as it is expected that the time required to suppress smouldering would decrease as the temperature of the gas decreased. An appliance producing such a gas by a conventional method at the rate of 600 ft^3/min has been available for many years and one incorporating a jet engine and producing 2,000 ft^3/min has been put on the market recently. If the gas however is to be used for bringing the fire under control by extinguishing or even merely reducing the intensity of flaming combustion then a much higher oxygen concentration (up to 14 per cent) may be tolerated and the gas temperature has only a marginal effect on the ability of the gas to control the fire. It is still important however, for the temperature of the gas to be sufficiently cool to allow firemen to enter the building to complete fire-fighting operations.

Limitations on size of appliance

The question was put as to why it was not possible to obtain cool gas of low oxygen concentration at rates comparable with the output of the J.F.R.O. generator. The weight of the appliance producing cool gas at a rate of 2,000 ft^3/min was 4 tons and the opinion was expressed that it was unlikely in the foreseeable future that larger quantities of a similar gas could be obtained with a comparable weight of appliance. The weight of the J.F.R.O. appliance producing 45,000 ft^3 per minute of a hot gas containing 7 per cent oxygen was 5 tons (including chassis). To obtain a comparable flow rate of cool gas containing less than 2 per cent oxygen would require an equipment estimated as weighing about 100 tons which would be quite impracticable. There were three reasons for this.

1. To obtain the cool low-oxygen gas it is necessary to burn out practically all the oxygen in the air fed to the appliance instead of only about 2/5 of the oxygen as in the J.F.R.O. appliance; for a given flow rate of gas this would require a much larger combustion chamber.

2. In order to cool the gas to the low temperature required the heat must be taken away only as sensible heat in the water supplied instead of predominantly by latent heat of vaporization as in the J.F.R.O. appliance. Thus for a given amount of heat removal there is a difference by a factor of about 30 in the amount of water required. The size and weight of the heat transfer equipment per unit volume of gas would therefore be far greater for the cool fully inert gas than for the hot semi inert gas.

3. In producing the cool fully inert gas the heat provided by the combustion is wasted and is carried away by the cooling water. In producing the hot gas the heat provided by the combustion is used to produce a large amount of steam. In the J.F.R.O. appliance the presence of this steam approximately halves the oxygen concentration (reduced from 12 per cent to 7 per cent) and doubles the total output (increases from 25,000 to 45,000 ft^3/min).

Effect of ventilation

The question was raised as to whether the second demonstration in the models laboratory did indeed provide an indication of the ability of the J.F.R.O. appliance to control large fires. There was a lack of ventilation in this test and the sizes of fires used were comparatively small. It was pointed out the object of this test was to demonstrate the ability of the appliance to clear smoke and ventilation had been restricted to allow the rapid smoke logging of the building. During the tests there was a natural ventilation area of about 30 sq. ft. Tests with similar types of fire with a ventilation in the roof of 200 sq. ft, and in the walls of 70 sq. ft, gave extinction of flaming combustion in 90 per cent of the volume of the building in about 10 minutes.

The maximum size of fire with which the J.F.R.O. appliance could cope had not been tested since no building which had been used for tests had been such as to allow this test to be carried out. However from tests on fully burning room fires it has been estimated that flaming combustion could be extinguished in about 15-20 rooms simultaneously each room containing an opening about 4 ft square and through which flames were passing.

Ancillary apparatus

The view was put forward that if the apparatus were to be used for fires on ships, even for certain inaccessible fires that might occur in cities, the length of ducting required would be upwards of 400 ft. It was stated that it should be possible for the 2 ft 6 in diameter collapsible ducting tested to convey the full flow rate of the J.F.R.O. appliance through a length of 400 ft provided that there were no sharp bends. If there were sharp bends it might be necessary to reduce the flow to prevent the engine stalling. It is feasible to use a number of smaller diameter ducts rather than one large diameter duct if these are more easily handled. There should be even less difficulty in providing the necessary length of ducting with appliances smaller than the J.F.R.O. appliance. The question was raised on the danger that may arise from hot gas if a duct burst. It was stated that from an open end there should be no danger beyond the distance of 20 diameters from the end of a duct; for a tear or leak the danger is unlikely to extend beyond a few yards from the duct.

Air foam - gas foam

Recent experience in the U.S.A. with high expansion foam produced by an air fan was mentioned and the question was raised as to whether there was any advantage in producing the high expansion foam with the jet engine appliance as opposed to a simple air appliance using an electrically driven fan. The latter apparatus would be very much cheaper and probably easier to handle. The following advantages for the jet engine generated foam was mentioned.

1. It was capable of extinguishing a wider range of fires. Air foam could not extinguish alcohol and similar fires easily and comparative tests had shewn that the jet engine foam extinguished petrol fires better than the air foam.

2. The foam could be produced at the point where it was wanted rather than at the appliance itself; on the other hand it had been found convenient to convey the air foam under some conditions using a polythene duct, the polythene being melted by the fire.

3. A much larger head was available to push the high expansion foam through doors and corridoors; with the jet engine generator at least 30 inches head of water pressure was available for this purpose whereas with an air foam generator the head available was unlikely to be greater than 1/3 rd of this. Alternatively this advantage could be used to push through a building a stiffer foam with a higher water content. The extra pressure available would also give an advantage in increasing the height of a column of foam which might be supported.

4. After collapse of the foam the gas inside the jet engine foam reduced the intensity of burning whereas the gas air inside the air foam increased it; on the other hand the air foam had a somewhat longer life and held water better than the jet engine foam because it was cooler.

High expansion foams in mines

It was stated that in mines fires it was impossible to fight the fire with a static high expansion foam since it was dangerous to stop the ventilation current in the narrow roadways. There was a toxicity and asphyxiation hazard associated with foam particularly when the latter was moving and it was unwise to allow inexperienced personnel to enter the foam.

Salvage

Damage which may be caused by either inert gas or foam will depend primarily on the water content of the medium and the length of time for which the goods are exposed to it. Experience with the high humidity high temperature gas of the J.F.R.O. appliance has indicated that exposure time for half hour to this gas was not likely to cause anything more than superficial damage due to moisture condensation and little damage to electrical circuits etc. Water can be absorbed from high expansion foam by articles such as cardboard boxes, particularly if these are on the floor of the compartment. A long term exposure of bulk material to any moist inert gas could result in the fairly uniform absorption of water by the bulk of the material to a degree which would depend on the water vapour content of the gas.

Future developments

It was generally felt that more operational experience was required in the use of jet engine foam and inert gas producers for fighting fires and these could best be obtained from appliances built for actual use by fire brigades. There was scope for appliances producing both relatively small quantities of cool gas of low oxygen concentration and for appliances producing large quantities of high expansion foam and gas on the principles developed by J.F.R.O.

APPENDIX I

SYMPOSIUM PROGRAMME

Thursday, 26th September

A.M.

Chairman: F.E.T. Kingman, B.Sc., Ph.D., F.R.I.C., (Joint Fire Research Organization).

9.50	Assemble in Conference Room.
10.00 - 10.15	Welcome and introduction by Chairman.
10.15 - 11.00	"The production and use of fire fighting media based on jet engines". Speaker: D. J. Rasbash, B.Sc., Ph.D., A.R.C.S., D.I.C., A.M.I.Chem.E. Joint Fire Research Organization
11.00 - 11.15	"Experience gained in the operation of the J.F.R.O. inert gas and foam generator". Speaker: G. W. V. Stark, B.Sc., A.R.I.C. Joint Fire Research Organization.
11.15 - 11.45	Coffee.
11.45 - 12.15	Discussion on morning papers.
12.15 - 1.00	Demonstrations.
1.00 - 2.30	Lunch.

P.M.

Chairman: G. R. Stanbury, B.Sc., A.R.C.S., F.Inst.P. Home Office.

2.30 - 3.30	Demonstrations.
3.30 - 4.00	Discussion.
4.00 - 4.30	Tea.

Friday, 27th September.

A.M.

Chairman: L. W. T. Leete, M.B.E.,
Chief Officer, London Fire Brigade.

9.50	Assemble in Conference Room.
10.00 - 10.05	Introduction by Chairman.
10.05 - 10.50	"Use of the foam plug process for fighting mine fires". Speaker: D. G. Wilde, B.Sc., Safety in Mines Research Establishment (includes showing of film)
10.50 - 11.10	Discussion.
11.10 - 11.40	Coffee.
11.40 - 12.15	"Use of inert gas for control of fires in ships". Speaker: F. Rushbrook, M.E.F.E., A.I.Mar.E., M.I.F.E., Firemaster, Edinburgh Fire Brigade.
12.15 - 12.45	Discussion.
12.45 - 2.15	Lunch.

P.M.

Chairman: D. I. Lawson M.Sc., M.I.E.E., F.Inst.P.,
(Director, Joint Fire Research Organization)

2.15 - 2.45	"Design of a jet engine inert gas and foam generator". Speaker: B. H. Slatter, B.Sc., A.F.R.Ae.S. Bristol Siddeley Engines Ltd.
2.45 - 3.05	Discussion.
3.05 - 3.40	Open Forum.
3.40 - 3.50	Closing address by Director of Fire Research.
3.50 - 4.20	Tea.

APPENDIX II

ATTENDANCE LIST

G. C. Ackroyd	Fire Offices' Committee
Chief Officer J. B. Vickery	Chief Fire Officers' Association
C. E. Neville	Institution of Fire Engineers
Dr. H. D. Taylor	Fire Protection Association
R. Rutter	" " "
H. A. Howe	D.S.I.R., H.Q.
Dr. G. V. G. Lusher	" "
R. E. Knowles	Ministry of Transport
J. Q. MacDonald	Ministry of Aviation
D. Andrews	Ministry of Public Building and Works
Commander R. L. Edmonds	Admiralty
E. A. Allen	Perkins Gas Turbines
K. H. Holliday	Lucas Gas Turbine Equipment
R. Humphrey	Pyrene
P. M. Pucill	Walter Kidde
Dr. J. W. Haworth	British Oxygen
C. Hunter	I.C.I.
D. P. Brodie	Marchon Products
W. A. Wood	National Coal Board
M. H. W. Browne	Central Electricity Generating Board
C. E. Fenna	" " " "
G. H. Bulmer	United Kingdom Atomic Energy Authority
G. T. J. Crafer	" " " " "
L. R. Parker	Merryweather
R. F. Kayte	W. C. Holmes
F. Broomhead	"
F. C. A. Shirling	Home Office
A. J. Leyland	" "
S. H. Charters	" "
J. D. F. Turnham	" "
G. R. Stanbury	" "
Dr. J. McAulay	" "
S. Gray	National Gas Turbine Establishment
E. M. Butcher	" " " "
A. H. Holden	Gibbons Brothers
C. T. Gildea	" "
R. V. Seels	London Salvage Corps
A. S. Pratten	" " "
Chief Officer L. W. T. Leete	London Fire Brigade
Divisional Officer R. S. Watts	" " "
Chief Officer G. V. Blackstone	Hertfordshire Fire Brigade
Divisional Officer E. J. Gunnett	" " "
Divisional Officer B. M. Doherty	Birmingham Fire Brigade
Chief Officer F. Taylor	Liverpool Fire Brigade
Assistant Division Officer Houghton	Lancashire Fire Brigade
Divisional Officer T. Bowrom	Durham Fire Brigade
Deputy Chief Officer F. C. Revelle	Bristol Fire Brigade
Chief Officer J. W. E. Jones	Glamorgan Fire Brigade
D. G. Wilde	Safety in Mines Research Establishment
F. Rushbrook (Firemaster)	Edinburgh Fire Brigade
Deputy Chief Officer F. S. Mummery	Middlesex Fire Brigade
Divisional Officer D. R. Squire	" " "
Assistant County Fire Officer D. A. S. Martin	Yorkshire (West Riding) Fire Brigade
Divisional Officer K. Horan	" " " " "

G. Stincombe	Austin Motor Co.
P. L. Henman	Sipon Products
P. H. Smith	New South Wales Government Offices
J. C. Bishop	Army Fire Service
W. H. Lindsey	Bristol Siddeley Engines
C. E. M. Preston	" " "
J. Chesterfield	" " "
B. H. Slatter	" " "
Mr. Barnacle	" " "
Director	Joint Fire Research Organization
Dr. F. E. T. Kingman	" " " "
Dr. D. J. Rasbash	" " " "
G. W. V. Stark	" " " "
J. F. Card	" " " "
B. L. Langford	" " " "
D. K. Freeman	" " " "
P. Nash	" " " "
R. W. Pickard	" " " "
C. J. Langdon-Thomas	" " " "

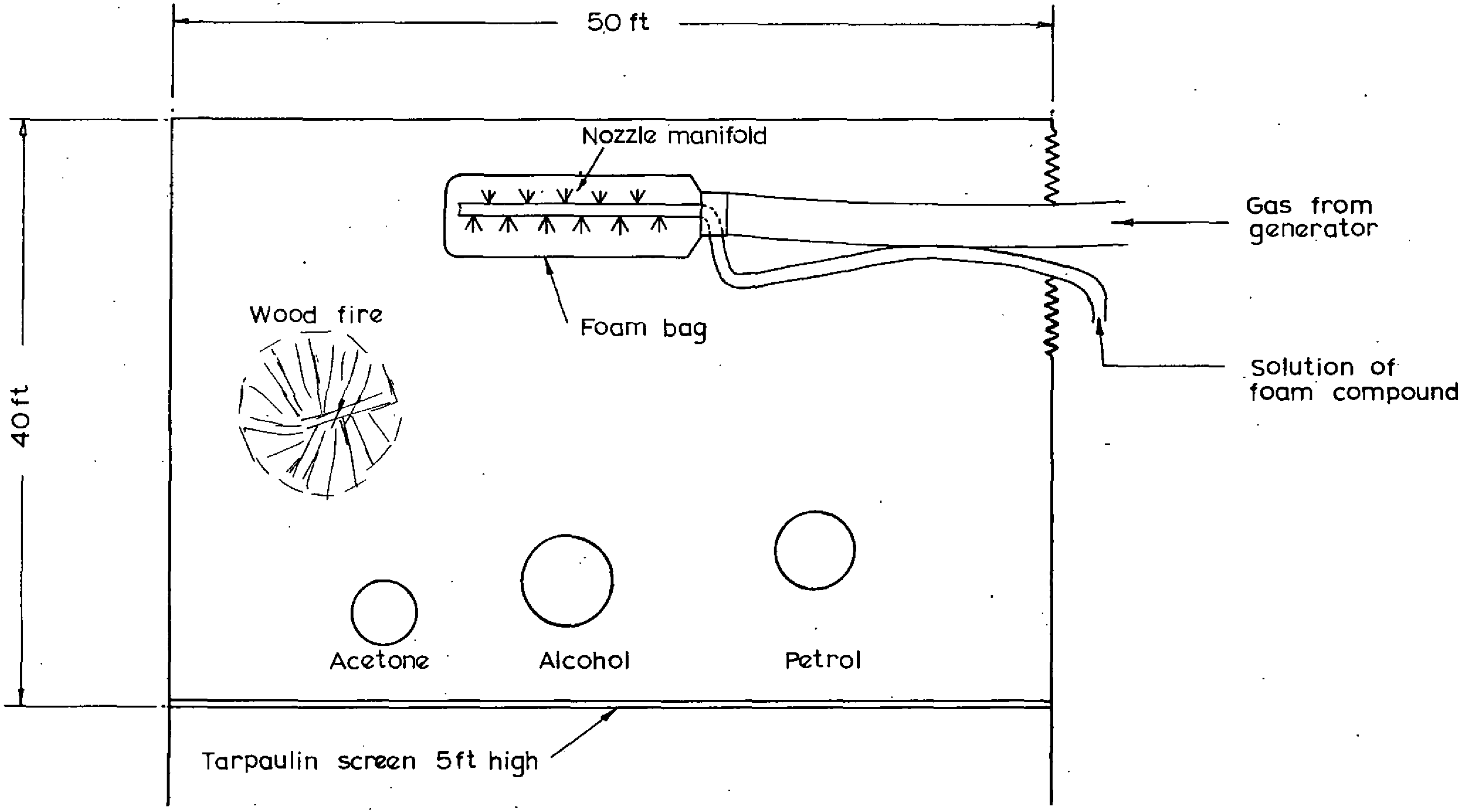
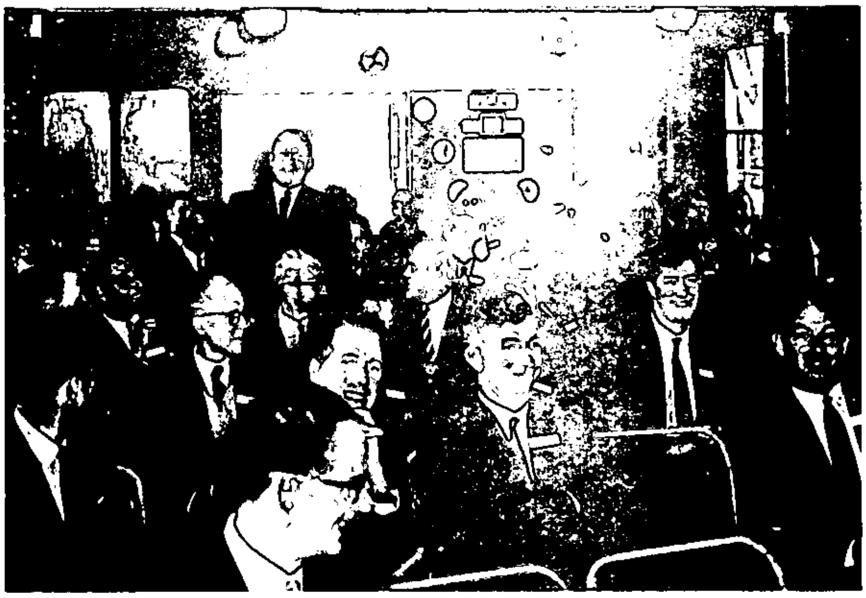
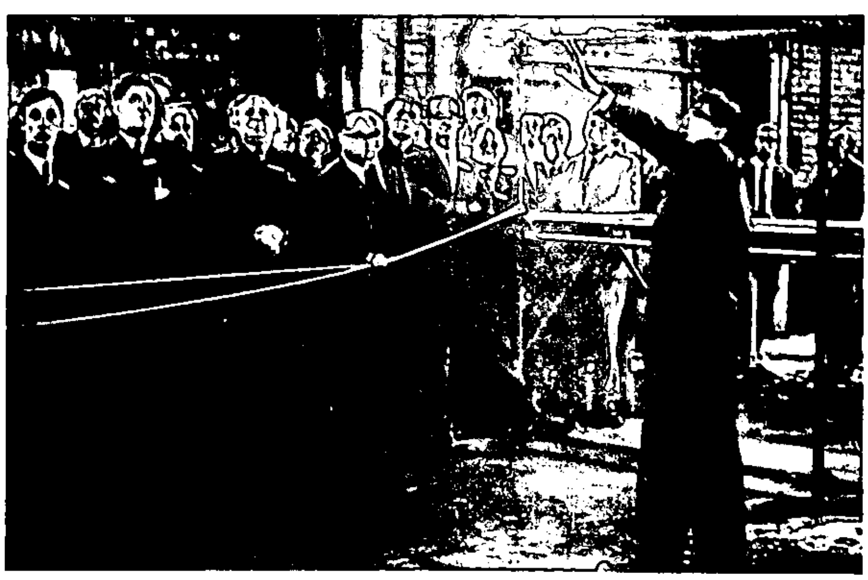


FIG.1. TEST AREA FOR INERT GAS GENERATOR FOAM SHOWING POSITION OF FIRES



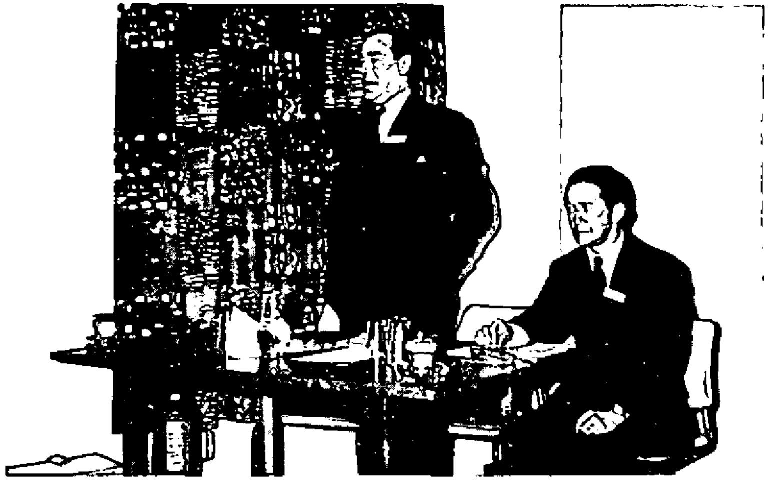
Audience during a discussion period

Audience in informal mood

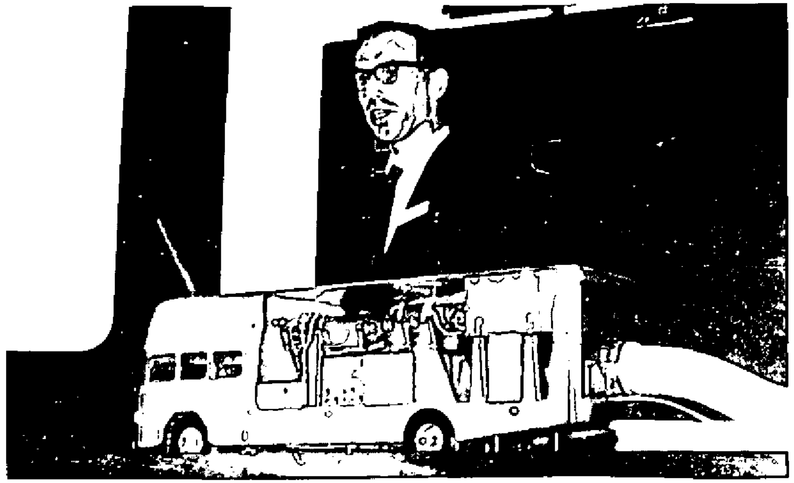


Briefing of audience before a test

THE AUDIENCE AT THE SYMPOSIUM

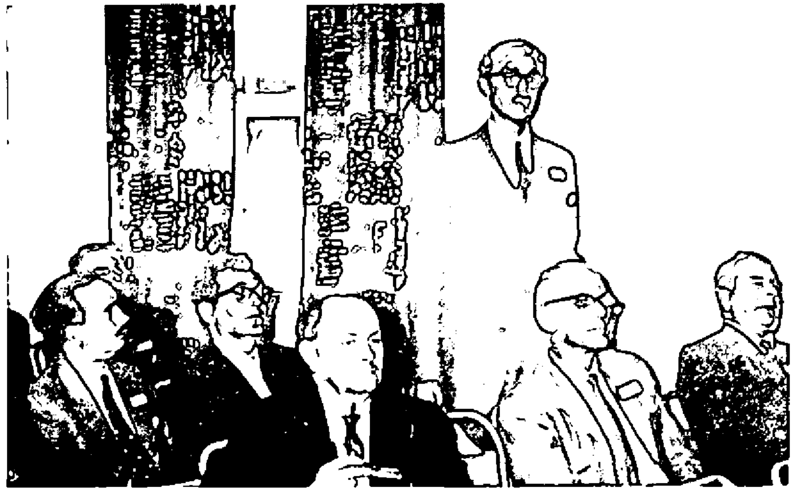


L. W. T. Leete, C.F.O.(London Fire Brigade) and
Dr. D. G. Wilde, (S.M.R.E.)



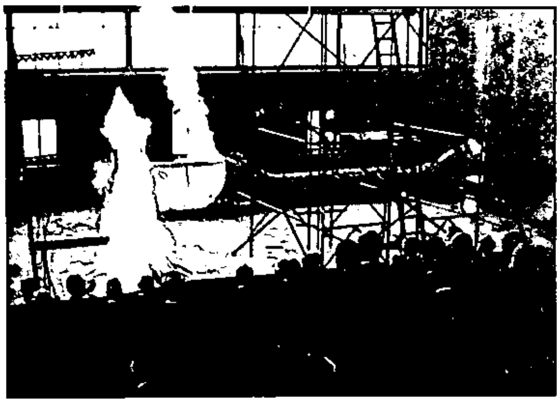
B. H. Slatter
(Bristol Siddeley Engines)

F. Rushbrook, Firemaster
(Edinburgh & S.E. Scotland Fire Brigade)

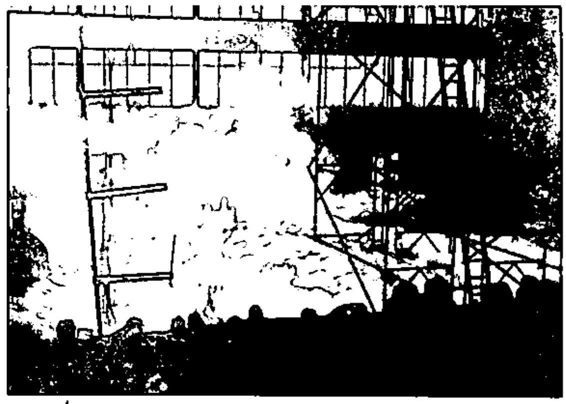


F. C. A. Shirling
(Home Office)

SOME SPEAKERS AT THE SYMPOSIUM



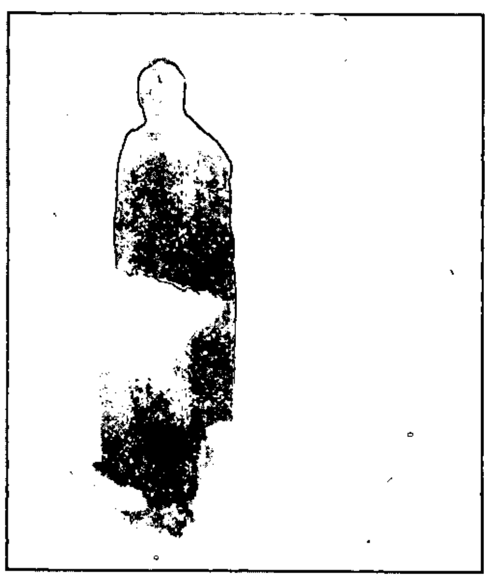
Ignited wood fire.
Foam bag in background.



Foam approaching wood, acetone and alcohol fires.
After 12 secs.

Foam approaching petrol fire.
After 20 secs.

Foam overrunning 5 ft barrier.
Ater 2 min.



Cutting path through foam with dry powder.

HIGH EXPANSION FOAM TEST

Ignition of 12 ft high wood fire.

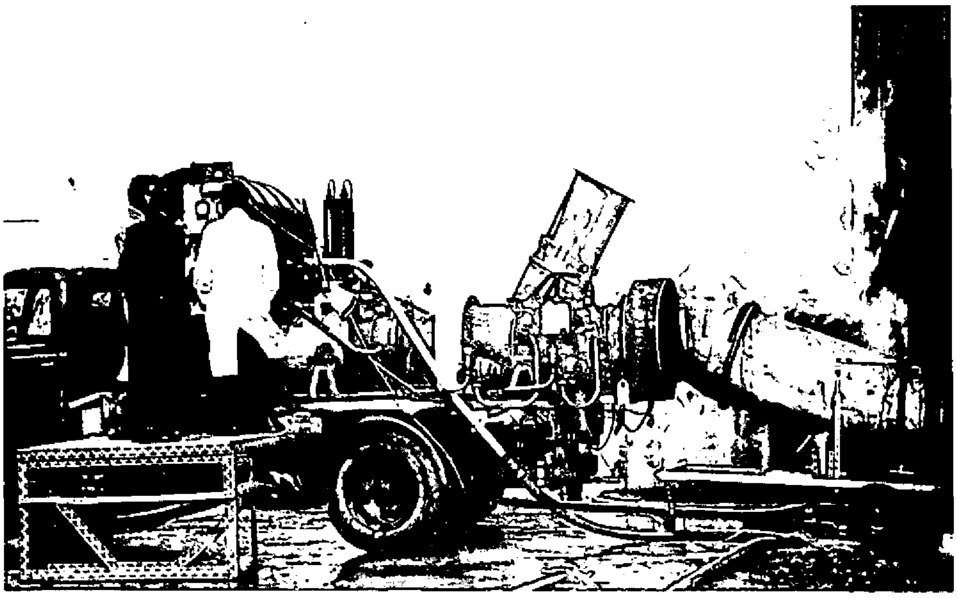
Ignition of one of the diesel oil fires.

20 ft pall of smoke. 1 min. burning of paraffin/petrol fire.

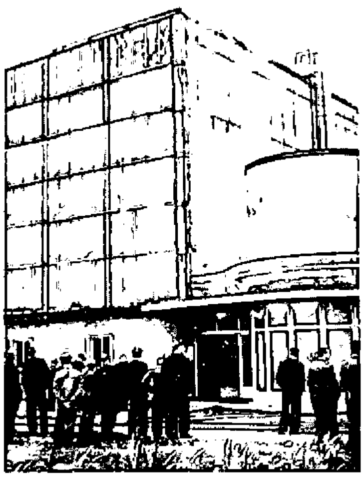
30 ft pall of smoke. 3 min. burning of paraffin/petrol fire.

35 ft pall of smoke. 5 min. burning of paraffin/petrol fire.

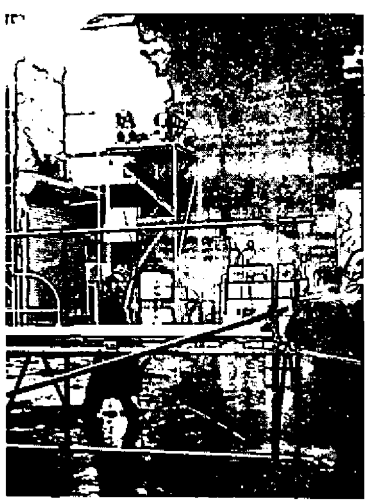
INERT GAS TEST IN MODELS LABORATORY-TEST FIRES



J.F.R.O. Jet Engine Inert Gas and Foam Generator.
Introduction of inert gas into Models Laboratory.



Escape of inert gas through light cladding
of Models Laboratory
10 min. injection



Models Laboratory after test.
All oil fires extinguished.
Wood fire smouldering.

INERT GAS TEST IN MODELS LABORATORY (CTD)