PROCEEDINGS OF A SEMINAR ON

MINE FIRES

BRISBANE, QUEENSLAND

NOVEMBER 12TH, 1973

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Organised by the Southern Queensland Branch, The Australasian Institute of Mining and Metallurgy, in conjunction with the Mines Departments of Queensland and New South Wales.

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PREFACE

A seminar on the cause and control of mine fires was held at Brisbane during November, 1973.

It was organised by the Southern Queensland Branch of the Australasian Institute of Mining and Metallurgy in conjunction with Mines Departments of Queensland and New South Wales. The seminar resulted from a recommendation made following an inquiry into a disaster at a Queensland coal mine.

The proceedings were led by Dr. H. L. Willett of Britain's National Coal Board and following his address six discussion groups were formed. Dr. Willett's comments on the reports submitted by those groups are included in these proceedings.

Contributions were made by all sections of the Coal Mining Industry including Mine Management, Mining Unions, Government Inspectorates and those concerned with Mining Education and Training in Australasia.

MINE FIRES SEMINAR

INTRODUCTION BY DR. A. J. LYNCH, CHAIRMAN SOUTHERN QUEENSLAND BRANCH, AUSTRALASIAN INSTITUTE OF MINING AND METALLURGY

Mr. Camm, Dr. Willett, Miss Jacka and Gentlemen,

I would like to welcome you all to this Seminar on Mine Fires which has been organised by the Southern Queensland branch of the Australasian Institute for Mining and Metallurgy. In particular I would like to welcome Dr. H. L. Willett, Deputy Director General (Special Duties) in the National Coal Board, United Kingdom, who will lead this seminar today and who is also giving a series of lectures on the causes and control of mine fires at various centres throughout Australia. It is an honour to have such a distinguished scientist and engineer as Dr. Willett with us. We are indebted to him personally for his willingness to travel literally around the world to give us the benefit of his knowledge, and to the National Coal Board for releasing him from his heavy duties for this seminar and for the support which it has graciously given us.

Dr. Willett is the Deputy Director (Special Duties) at the National Coal Board.

He is Chairman of the National Safety Committee of the coal industry in Britain and a visiting Professor of the University of Strathclyde. He was President of the Institution of Mining Engineers during the year 1970 - 1971. In January 1972 he was awarded the Institution's Medal, which is the highest honour the Institution of Mining Engineers can bestow, in recognition of his outstanding services in the science of Coal Mining particularly with regard to explosions in mines, recovery work, spontaneous combustion and safety in general. He is also the author of a text book dealing with colliery explosions and recovery. Dr. Willett will be the leader of the seminar which will proceed through the day and will also review our work in the speech after dinner this evening.

We have received assistance from many organisations in arranging this seminar and I will acknowledge these during the evening session. In particular, I would like to acknowledge the invaluable assistance and enthusiastic support which we have received from the Honorable R. E. Camm, Minister for Mines and Main Roads, and his officers in the Department of Mines. It is as guests of Mr. Camm that we are here today using the facilities of this Main Roads building. Mr. Camm has been a valued friend of the Southern Queensland Branch of the Institute for many years and has participated in many of our activities.

The seminar will take the form of an address by Dr. Willett followed by a question and answer period during the morning session. After lunch we will divide into six discussion groups each of which will consider some aspect of the cause and control of mine fires. Later in the afternoon we will meet together again and each group leader will report on the matters which were discussed by his group and submit questions for Dr. Willett's comments. The chairman of the morning session will be Mr. W. Roach, Chief Inspector of Coal Mines in Queensland, and of the afternoon session Mr. R. Menzies, Chief Inspector of Coal Mines in N.S.W.

I would now like to ask Mr. Camm to open the session.

MINE FIRES SEMINAR

OPENING ADDRESS BY THE HONORABLE R. E. CAMM MLA,

MINISTER FOR MINES AND MAIN ROADS

Dr. Lynch, Miss Jacka and Gentlemen,

I thank you and your Institute for your kind invitation to open this seminar on the cause and control of mine fires this morning. As Minister for Mines in this State of Queensland I have a vested interest in Safety in Mines. It is particularly pleasing to me to be with so many people associated with the industry and in fact those in charge of and reponsible for safe conduct in mines who obviously share my concern on the importance of this subject so vital to the industry.

I am sure there will be a great deal to be learned and implemented from the talk and discussion which will take place here today. In particular everyone will be looking forward to hearing from our distinguished and learned visitor from the United Kingdom. Dr. Willett's standing as a mining engineer places him in the forefront with international experts in this field. We are indeed honoured that he has taken time to visit Brisbane and lead the discussions which will occur. I would also like to extend a special and warm Queensland welcome to our many visitors from all States of the Commonwealth which includes Tasmania and also from New Zealand.

As you may be aware, this seminar, organised by the Australasian Institute of Mining and Metallurgy's Southern Queensland Branch, was mainly set in motion as a result of a major disaster in this State. An Inquiry finding is hereby put into practical effect. I wholeheartedly support, and in fact have to a large extent initiated the action now evidenced by Dr. Willett's visit and this gathering today. I sincerely trust that you assimilate much of the knowledge on this subject, which he has documented as a result of the considerable research into the cause and control of mine fires. It is most important that you are fortified by knowledge that may avert tragedy and disaster. I believe the biggest step we can take towards improved levels of safety in our mines, is to have high regard for your technical training and to administer that training by good housekeeping in your mines.

We must aim initially, to ensure that safety is regarded as a joint responsibility. A miner who engages in an unsafe practice endangers his fellow workers. A mine manager who does not insist on safe working practices at all times endangers the entire well being of the community. The administrator, or employer who closes his eyes to safe and proper practice by those within the ambit of his jurisdiction has grave responsibility.

An awareness of safety and its importance is clearly dependant on certain factors. Two of these are education and implementation. The success or failure of an education programme in the final analysis, is going to depend on the willingness of all those concerned to both learn and implement. Science is continually finding better answers to old problems as well as new answers to new problems.

Today the mining industry throughout the entire world faces many difficult environmental problems. These problems at this stage are not entirely insurmountable, they can be resolved. Nevertheless many of our mining problems have always been with us and perhaps will continue. A new mine is not like a new factory, we cannot leave our problems with the past. Our old enemies in fire, inundation and the like continue with us. On the other hand research has given many answers, as will be made known by Dr. Willett today.

The considerable research on the subject of mine fires as carried out throughout the mining world, and the results obtained are laregely known to Dr. Willett who has played a major role in research and particularly as an author in the documentation of results of research. I am informed by the Queensland Chief Inspector of Coal Mines, Mr. Roach, that Dr. Willett with his extremely high academic qualifications, his representation on various International Panels and Commissions, his authorship of outstanding technical publications, together with his forty-nine years of practical experience in mines, mark him as an outstanding world authority in mining.

One cannot have other than the highest regard for a man such as he who does not hesitate to impart his specialist knowledge to others.

On behalf of the Government as well as the mining industry, I would ask Dr. Willett to convey our since thanks to Mr. Ezra the Chairman and to the members of the National Coal Board for making his valuable time available to us. I trust his stay and visits throughout the mining areas in Queensland have been pleasant though perhaps tiring.

The success of this seminar, in the final analysis will be measured by results. We have here all the elements of success. I trust you spread and implement the message far and wide when your deliberations have concluded tonight.

It now gives me much pleasure to declare this Seminar open.

ADDRESS BY DR. H. L. WILLETT, DEPUTY DIRECTOR-GENERAL (SPECIAL DUTIES) NATIONAL COAL BOARD, AT THE SEMINAR ON MINE FIRES ON 12TH NOVEMBER 1973 AT BRISBANE, QUEENSLAND, AUSTRALIA

INTRODUCTION

A fire underground is potentially a very dangerous occurrence both from the point of view of possible poisoning by carbon monoxide and possible explosion. There is the further oint that on many occasions an underground fire has resulted in the need to seal off substantial areas of a mine and the equipment.

I propose to begin my talk by referring briefly to five of the disasters which have occurred as a result of fires underground which illustrate the importance of taking every possible precaution to prevent fires in mines.

The first example was a conveyor fire. It occurred at Creswell Colliery Derbyshire in 1950 and caused the death of 80 men on account of carbon monoxide poisoning. The fire occurred at a transfer point of a conveyor in an intake airway as a result of torn belting. The conveyor belt was made of rubber nd the fire spread rapidly along the belt and along the wooden lagging of the road. The fire travelled 125 yards in the first one and a half hours and in total it travelled a distance of over 600 yards along the intake roads. Poisonous fumes reached the nearest coal face one and a quarter miles inbye the starting point of the fire in fifteen minutes, and reached other coal faces one and three quarter miles inbye the starting point of the fire in 27 minutes. Some of the men managed to escape by rushing along the return airways but others were overtaken by the fumes and died as a result some 30 minutes or so after the fire started.

This fire drew attention to the inflammability of rubber conveyor belting and steps were immediately taken, in association with the belt manufacturers, to develop a suitable type of conveyor belting which was fire-resistant. Only fire-resistant belting has been permitted for normal conveyors in British mines since 1952. The type of belting we use is P.V.C. We have 3000 miles of such conveyors.

The next disaster I refer to occurred at Marcinelle Colliery in Belgium in 1956. At this mine there were two shafts 1000 yards deep and 30 yards apart. Coal winding was done in the downcast shaft. At the bottom of the downcast shaft there was a hydraulically operated balancing platform for loading the cages and this was fed by oil through a 3 inch diameter pipe from a tank in an inset 70 yards above the bottom of the shaft. The tank contained 850 litres of oil. Adjacent to the oil pipe there wereelectric cables and a compressed air pipe.

The cage was signalled away without the onsetter knowing that a mine car was protruding due to faulty loading. As the cage ascended, the protruding mine car broke a girder in the shaft which in turn broke the oil pipe a few yards above the bottom of the shaft giving a spray of oil. The broken girder damaged the electric cables producing an electric arc and it also broke the compressed air pipe. Thus there were ample ingredients for a serious fire.

A fair amount of timber was used in the lining of the shaft and in the connecting slit between the bottom of the downcast shaft and the upcast shaft. As a result the fire spread quickly to the bottom of the upcast shaft. In fact the fire reached there about one hour after it had started, thus cutting off all means of ingress or egress into the mine. Two hundred and sixty-one (261) men who were underground at the time died of carbon monoxide poisoning.

A different type of fire occurred at Auchengeich Colliery in Scotland in 1959. A Balata transmission belt of an electrically driven booster ventilating fan came off the fan pulley and jammed. The resulting friction caused a fire which ignited oil from the bearings of the fan shaft. The fire spread quickly downwind to ignite timber at the roof and sides of the road. Men were travelling into the district at the time by means of a manriding haulage in the return airway. Forty-seven (47) men died as a result of carbon monoxide poisoning. This fire illustrated once more the speed at which lethal percentages of carbon monoxide can be produced in underground roadways following a fire, and the need to take precautions to withdraw men as quickly as possible by a safe route. The atmosphere developed from a slight haze and smell to a lethal atmosphere in about half an hour despite the large quantities of air.

Two technical improvements were made following this fire. The first was to require that all power transmission belts used underground should be fire-resistant. The other precaution taken was to ensure that roads in the vicinity of underground fan houses should not contain inflammable material.

An explosion resulting from the ignition of methane by a spontaneous heating occurred at Bickershaw Colliery, Lancashire, in 1959, a few hours after the district had been sealed off. At the time men were working at the return stopping increasing its length. Five of these men died from carbon monoxide poisoning as a result of the explosion behind the seals. The lesson stressed by this particular accident was that no one should be allowed to remain in the vicinity of the stoppings for some time after the stoppage of the ventilation by sealing. Any period of time chosen for this purpose must of course be an arbitrary one. We decided that a reasonable period during which nobody should be allowed to be in the vicinity of the stoppings after a fire had been sealed off would be 24 hours.

At Michael Colliery in Scotland a length of road in the coal near the shaft bottom was lined with polyurethane foam to prevent air leakage. However, in 1967 spontaneous combustion of the coal occurred behind the polyurethane foam. The foam had not been treated with a fire-retardant coating and as a result the polyurethane foam burnt very rapidly and a lethal atmosphere soon resulted. Tests carried out in a surface gallery after this fire indicated that the burning of the polyurethane foam produced considerable quantities of carbon monoxide and of carbon dioxide and resulted in the oxygen content being almost nothing. Nine men died as a result of the fire but fortunately the other three hundred and five (305) men underground were withdrawn safely.

This fire illustrated once again the importance of officials and workmen having clearly in their minds the speed at which the products of a fire can travel round the mine and lead to danger to all concerned unless suitable precautions are taken. The fire also demonstrated the importance of banning polyurethane foam from use underground and of introducing a system of approvals for materials used underground for sealants and coatings used to line roadways in order that only materials which were known to be incombustible were used. I will refer to some of the materials we have introduced as a result at a later stage in my talk.

MAIN CAUSES OF FIRES

In British coal mines there are on average about 50 underground fires each year of which about 30 are associated with belt conveyors and 10 are of electrical origin. The number of conveyor fires can only be seen in perspective by having in mind that there are 3000 miles of conveyors in British mines. Large fires are rare in British mines. In fact, we average only one or two of these a year. At least half of the fires are discovered whilst they are less than about 2 square feet in area. Nevertheless, as I have already indicated, all underground fires are potentially serious.

Of the belt conveyor fires about 15 a year are caused by collapsed bearings in the bottom idler rollers. About 5 a year are caused by overheating of conveyor brakes.

Over a half of the electrical fires are associated with cables, cable couplers and adaptors - in some cases after power has been restored to faulty equipment. Examples of other electrical fires which we have had in recent years are as follows.

A severe shortcircuiting developed across the fixed and moving main contacts of a flameproof gate-end box used to control a main gate conveyor motor and caused excessive internal pressure which blew off the main contactor chamber cover. Arcing apparently caused thermal decomposition of the insulated moving main contactor bar and the insulated base board with the evolution of a gas mixture which increased to an abnormally high pressure. Research is proceeding at the Safety in Mines Research Establishment, Buxton, on the effects of arcing on insulation and the mechanism of resulting pressure build-up in flameproof enclosures.

Another fire was caused due to the failure of a bearing of a flameproof motor for driving a trunk conveyor shortly after the motor had been fitted. Investigations showed that grease on the bearings had been contaminated with dirt and this demonstrated the advisability of replacing flameproof motors as complete units rather than undertaking component replacement work in unsuitable underground conditions.

Smoke was seen followed by a flash and flames when an open circuit occurred in a charging lead a short time after a locomotive battery had been put on charge in an underground charging station. The occurrence revealed the need for care in the regular testing and checking of charging leads. A sensitive earth leakage device is being developed for use on such D.C. equipment as the type of locomotive to which I have referred.

As an additional example, some of you will know that there was an explosion in 1951 at Weetslade Colliery, Northumberland, as a result of the shortcircuiting of the shuttle car battery caused by the falling of a metal tool.

On a 100 horsepower diesel locomotive the driver saw flames issuing from the engine compartment while hauling cars carrying 120 men. The fire was quickly extinguished and the subsequent examination revealed that a copper fuel pipe sited over the exhaust manifold of the engine had fractured. These pipes have now been re-routed on the other side of the engine and the maintenance schedules have been amended to specify regular replacement.

The third main cause of fires in mines in Britain is the spontaneous combustion of coal. But as this is rather a large subject and I shall take some time to discuss it in relation to your problems in Australia, I will first of all round off what I have just been saying by indicating some of the general means we adopt to prevent or to restrict the spread of friction type fires.

FIRE-RESISTANT MATERIALS AND PREVENTING THE SPREAD OF FIRE

Considerable progress has been made in recent years in the introduction into British mines of fire-resistant hydraulic fluids in place of mineral oil. For example, we have now more than 4000 water filled fluid couplings. Some non-toxic phosphate esters are also used. But the principal fire-resistant fluids in use are 60 oil/40 water (invert emulsion) and 5 oil/95 water (direct emulsion - used on hydraulic powered supports).

Since we introduced fire-resistant conveyor belting we have not had any case where a fire has been propagated along a roadway by means of the belt. The main cause of propagation of fires has been the timber lagging behind the roadway supports. In order to prevent this means of propagation of fire, we have gradually introduced timber treated with fire-resistant salts, the main ingredient of which is ammonium sulphate. At the present time approximately two-thirds of the wooden cover boards we purchase for lining roadways are impregnated with such materials. The policy is to extend this impregnation until no cover boards other than fire-resistant ones are used.

All ventilation ducting, brattice cloth and hose pipes used underground in British mines are required to comply with specifications regarding their fire-resistant and anti-static properties.

In order to prevent the spread of a fire at conveyor transfer and loading points and at the sites of booster fans, the roadways are lined or treated in such a way as to make them fireproof for some distance. The installation of integrated remotely controlled belt conveyor systems has led to the development and application of devices to monitor belt slip, torn belt, belt alignment on gear heads, overheating and chute blockage. Special precautions have also been taken regarding the requirements for regular maintenance of reciprocating air compressors and the frequency of inspection and topping-up of the conditioner boxes of locomotives.

I have referred to the fires caused by idler rollers on conveyors. We have found that these can be minimised by adequate patrolling and maintenance of the belt conveyors.

In view of the number of fires which have been caused by flashes from electric cables, you will be interested to know what we have done in an attempt to eliminate this danger.

For many years the practice in Britain has been to use 550 volts at the coal face fed from a transformer with the neutral point solidly earthed. As mechanisation at the face increased so did the damage to the flexible cables supplying the coal face cutting and loading machines. This damage resulted in electrical faults which could release up to several thousand amps at the fault with attendant flashing and consequent danger of burning and explosion of methane.

To reduce dangers from such causes flexible cables were manufactured with flame retardant properties; all power conductors were individually screened with a flexible copper braid which was attached to the general body of earth; and steps were taken to reduce the current which could flow in an earth fault.

To reduce the fault current the measures taken were to connect a reactor in the neutral connection of the transformer which restricted the current in the earth fault to a maximum of 15 amps. This precaution was further improved on by the development of a system of sensitive earth fault protection which limited the earth fault current to three quarters of an amp. This equipment is electronic in nature and designed to "fail safe", that is, any component failure occuring in this protection device would cause the switch to open and to remain open until the equipment was changed or repaired.

All coal faces in British coal mines are now provided either with restricted or sensitive earth fault protection.

The action taken in regard to transformers has been to change over gradually from the mineral oil filled transformer to the flameproof air cooled type. This coincides with a gradual changeover from the use of 550 volts at the coal face to 1100 volts.

SPONTANEOUS COMBUSTION

Spontaneous combustion of coal - that is the self-heating of coal - is caused by oxidation. In this process, the oxygen in the air combines chemically with the coal and generates heat. If the heat can be dissipated quickly the temperature of the coal does not rise appreciably and fire does not take place. But if there continues to be a flow of air over or through the coal, and the heat is not dissipated, the temperature increases considerably. At these higher temperatures the coal absorbs oxygen faster and the temperature rises more rapidly. Unless the oxygen supply is cut off a fire will occur.

Experience has taught us that it is not only the capacity of the coal to absorb oxygen which is important. It is also the circumstances in which the seam occurs underground, the type of strata above and below the seam, the thickness of the seam, and the method of working the coal. As a result of all these factors some coal seams are more liable to spontaneous combustion than others. Some are extremely liable and many heatings result. At some collieries there are no cases of spontaneous combustion.

The thickness of the seam and the method of working are extremely important factors in regard to the liability to spontaneous combustion. Over 90 percent of the coal in Britain is produced from longwall workings and we have had much experience of spontaneous combustion in such workings particularly in the vicinity of where a coal face starts and where it finishes. But it became quite clear to me during my visits to mines in Queensland last week that there would be little advantage to you if I were to dwell on the incidence of spontaneous combustion in longwall workings. In order to be of greatest assistance I shall concentrate today essentially on the subject of spontaneous combustion in room and pillar working and other methods of working involving headings in the solid coal.

At some mines heatings at the sides of coal pillars are the most frequent cases of spontaneous combustion. When breaks occur at the sides of coal headings they result in the production of coal dust in a form conducive to oxidation and, of course, they result in the production of channels which conduct air currents to it. Heatings from this cause occur particularly where the control of the strata at the roadside is inadequate, for example at some junctions. Prevention, therefore, is firstly a question of adequate roof support.

Heatings very often occur in the circumstances I have described in the vicinity of ventilation doors or regulators. Unless the wall for the framework of the doors is extended into the sides of the road as far as the solid coal beyond the breaks, the difference in ventilation pressure between the two sides of the doors will result in a flow of air through the breaks and conditions will be particularly conducive to spontaneous combustion. Many heatings have been caused in this way. The precaution we take to try to prevent them is to extend the wall to the solid coal. Solid coal is only very slightly permeable to oxygen and other gases, so spontaneous combustion can only occur when breaks are induced. Our job is to ensure that strata control is such that the solid coal at the sides of the road is not broken - or, if breaks do occur, that action is taken to prevent air leaking through the breaks.

Another type of heating we have had in thick seams is at overcasts where the return road passes over the intake road, some coal having been left between the roof of one road and the floor of the other. Leakage of air from the intake to the return at such places has resulted in oxidation of the coal in breaks. The action we take to prevent such heatings is to remove the coal between the two roads and to replace it with either concrete or Hardstop (a gypsum).

In thick seams spontaneous combustion often occurs as a result of a fall of coal and other carbonaceous material from the roof. Oxidation takes place and fire occurs. In confined situations it may be quite dangerous to use water on such fires and other methods must be adopted. If water is used steam accumulates near the roof and it is impossible to see what danger lies above. Falls may occur without warning and the steam makes it more liable for further falls to occur. But perhaps a more serious potential danger is that the action of the water on the burning coal or other carbonaceous material may produce sufficient hydrogen, possibly added to by high percentages of carbon monoxide, which will result in an explosive mixture of fire gases. In a confined area without through ventilation there is the serious possibility that this might occur and cause an explosion. The use of sand or other inert material to blanket the fire while the material is removed is a practical proposition and a much safer one than the use of water in the circumstances described.

Although I do not intend to take up time in discussing longwall advancing methods you may, of course, in your circumstances wish to adopt longwall retreating in some cases. One of the difficulties with such a method of working is that there may be dangerous emissions of inflammable gas from the goaf unless action is taken to remove or otherwise keep the gas under control by means of a bleeder system or other suitable method. The bleeder system has proved popular in America but care is necessary in deciding whether it is the appropriate method to use in a seam liable to spontaneous combustion. There have been cases where the gradual movement of air in the goaf has led to spontaneous combustion and the need to seal off the district. For that reason we have tried other methods of preventing dangerous emissions of gas from the waste.

In order to form a retreating longwall face it is necessary to drive headings for the intake road, the return road and the coal face. Once this is done there is sometimes a tendency to start to retreat the coal face and thus form a small area of goaf before it becomes possible to retreat the coal face at the pre-determined rate. The conditions so induced are conducive to spontaneous combustion. The advice I give in respect of the starting up of a longwall retreating face in a seam liable to spontaneous combustion is to form the face and then not retreat at all until everything is ready for retreat to take place rapidly.

Another point to have in mind regarding retreating longwall faces is that when the face has retreated to its limit the equipment should be withdrawn as quickly as possible and the district sealed off otherwise heating is likely to occur in the worked-out area.

Many of you will know that inhibitors were used to prevent the heating of certain copper ores at Mount Isa mine. Profiting by this work we have carried out tests in the laboratory with inhibitors with coals liable to spontaneous combustion. The work is very much in its infancy.

SEALANT COATINGS AND COATINGS

I mentioned early in my talk that following the disaster at Michael Colliery in Scotland in 1967 we prohibited polyurethane foam for use underground. Following that decision we developed, with the help of various manufacturers, sealant coatings and coatings which are non-combustible and do not present health or safety hazards.

Two examples of these are Mandoseal, which is a mixture of exfoliated vermiculite and Portland cement with suitable additives, and Gypseal which is basically exfoliated vermiculite and gypsum. These materials are sprayed on to the sides of the road to a thickness of about one inch which is sufficient to prevent air leakage in normal circumstances. The materials tend to adhere very well to coal but if the materials on the sides of the road are such that adhesion is not very good, then wire netting is used on which the material sticks very well.

In addition to these two materials and other materials designed to be sprayed on, we have a good result by using Hardstop (which is basically a gypsum) when applied behind shuttering for sealing the roof and sides of the road. With this type of material it is usually found necessary to have a thickness of material of about 4 to 6 inches between the shuttering and the roof and sides of the road.

In some cases it is necessary to do more to seal the sides and roof of the road than simply to apply a sealant coating. In such cases we bore holes and inject either concrete or gypsum or Mandoseal or some other material which has appropriate setting qualities.

BALANCING THE VENTILATION PRESSURES ON SEALED-OFF AREAS

Spontaneous combustion often occurs in worked-out districts. In some cases this arises because the worked-out area has not been properly isolated by stoppings. In other cases spontaneous combustion occurs despite the building of stoppings on account of differences in ventilation pressure across the sealed off area which lead to air leakage through the area.

It goes without saying that the first step to prevent spontaneous combustion in a worked-out area is to build proper stoppings. One means of preventing the incidence of spontaneous combustion in old districts is to have planned the area in such a way that there is the minimum number of entrances and then to balance the ventilation pressures on the stoppings built in those roads.

An example of an extensive area requiring 78 stoppings to seal it off is illustrated in Fig. 1. It proved quite impossible to prevent air leakages in that case.

Figure 2 illustrates a more modern method which facilitates effective sealing with few stoppings.

Though stoppings built in strong unbroken strata can often be made quite airtight, there are many situations underground where the type and thickness of the stoppings and the condition of the site are such that air or gas could pass around or through them with very small ventilation pressure differences. For this reason, in order to prevent spontaneous combustion in a sealed area, the ventilation pressures on the outer faces of the stoppings should be maintained at such values as to prevent as far as practicable circulation of air through the sealed area.

It is often found that the pressures on stoppings can be nearly, but sufficiently, balanced by removing or adjusting doors in roadways connecting the outbye sides of the stoppings (see Fig. 3). If it is possible to erect further stoppings in the intake and return roads outbye the open connecting road, thus further isolating the system from the pit ventilation, an almost perfect balancing of the pressures on the faces of the inner stoppings can be achieved (see also Fig. 3).

In cases where there are roadways which lead to a sealed area and which cannot be connected by a pressure balancing roadway, it may be possible to balance the pressures on the stoppings by means of a ventilating duct (see also Fig. 3).

It will often happen, however, that there is no convenient connecting road which can be used as a pressure balancing road and that the stoppings are too apart for it to be practicable to connect them by pressure balancing ducts. In such cases, in order to balance the pressures, it is necessary to use a pressure chamber for each individual stopping.

A pressure chamber is constructed by

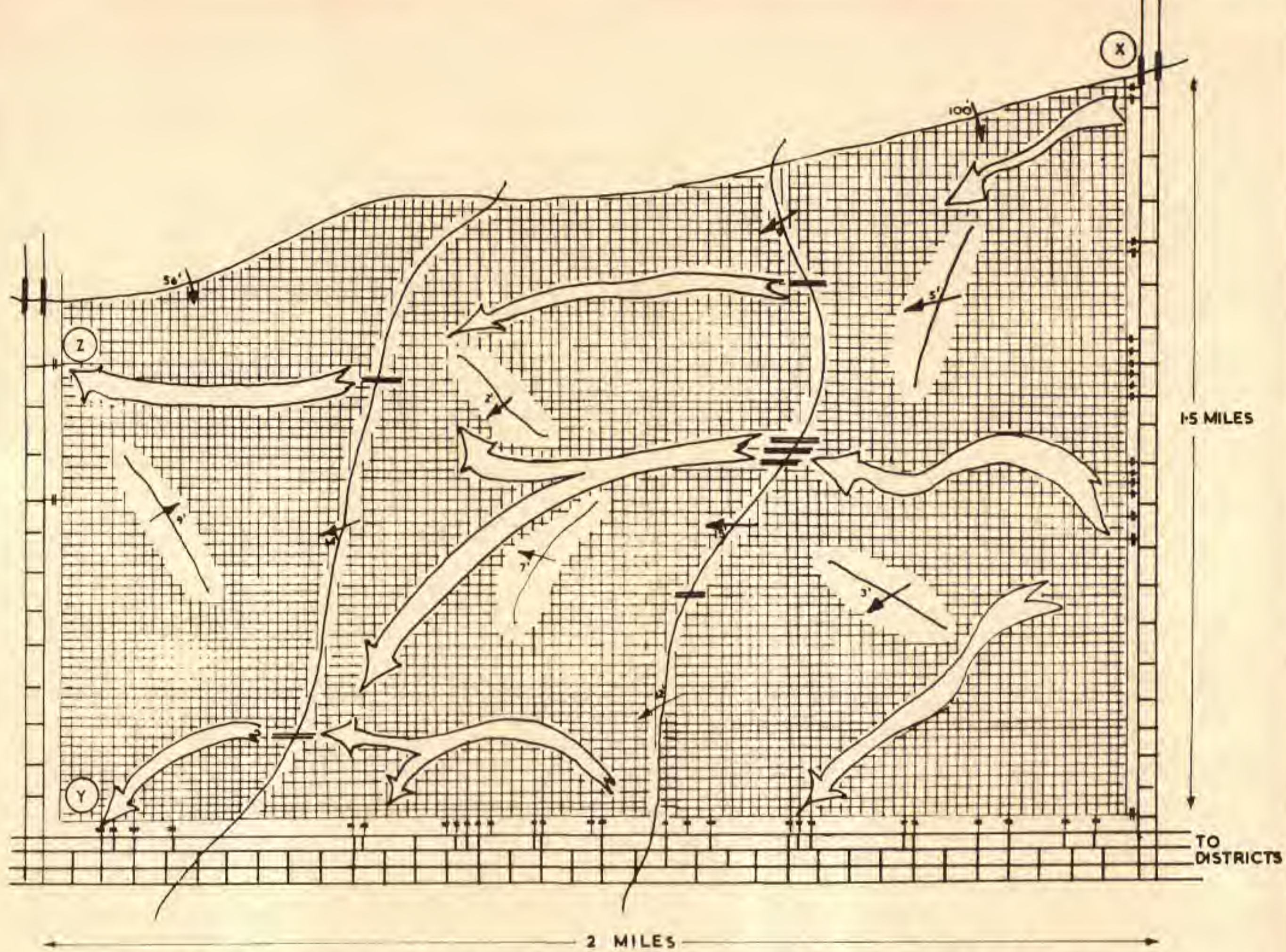
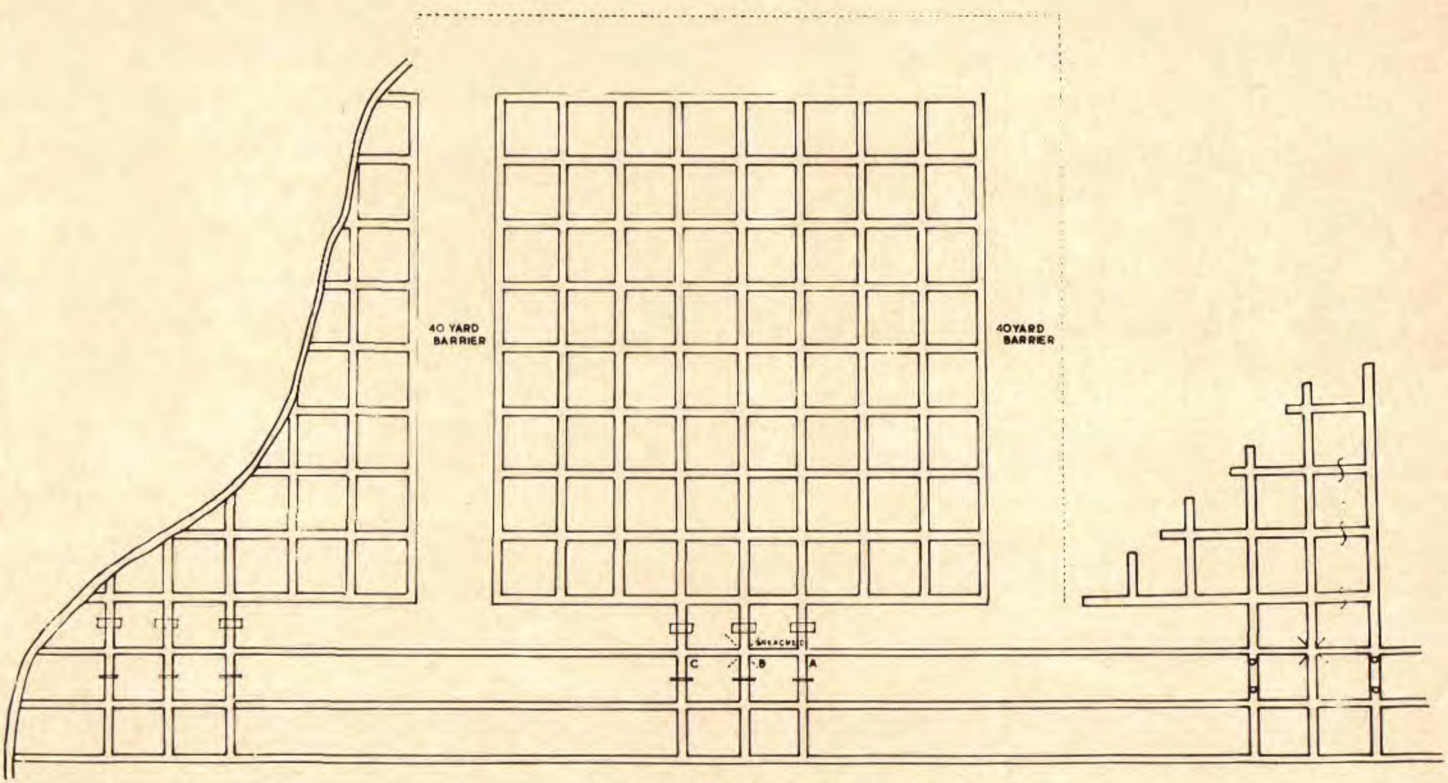


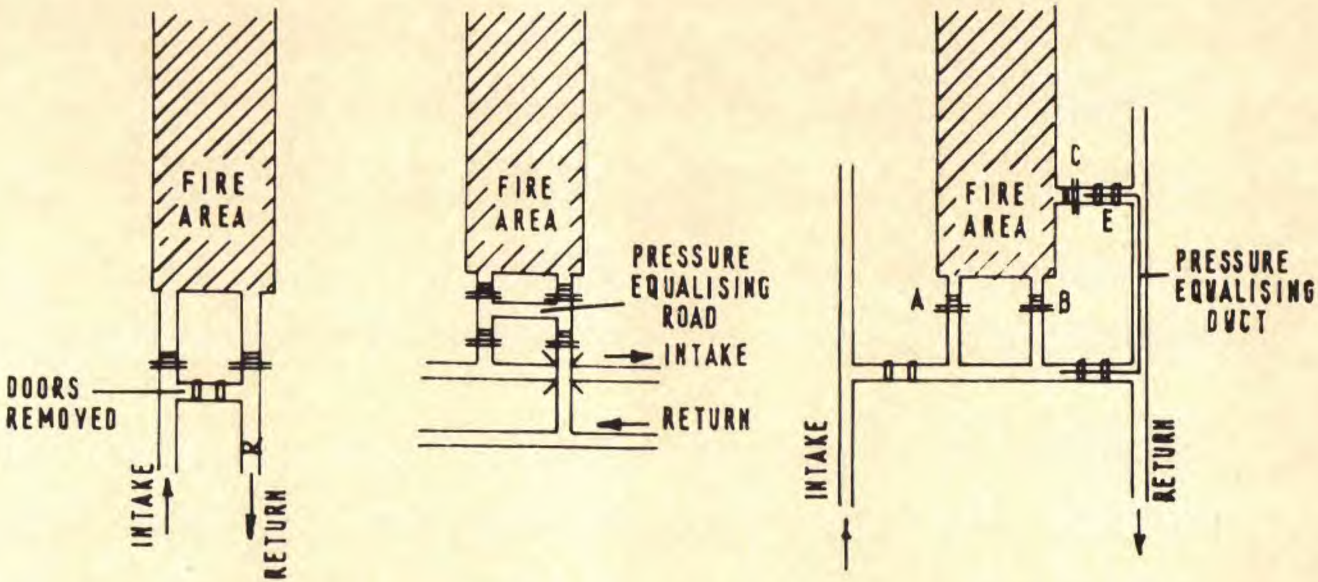
FIGURE 1 EXTENSIVE INTERCONNECTED ROOM AND PILLAR WORK



PRESSURE OVER PANEL IS MINIMISED TO THAT OF 'A' TO 'C' WHICH IS A FUNCTION OF 'Q' AND 'R' BETWEEN THEM.

BACK OF STOPPING 9 YARDS FROM MAIN AIRWAY TO PERMIT THICKENING OUT TO 5 YARDS AND THE PROVISION OF A CHAMBER STOPPING ABOUT 1 YARD IN IF NECESSARY. STOPPING EQUIPPED WITH SAMPLING PIPE.

FIGURE 2 TYPICAL ISOLATED PANEL FOR MECHANISED ROOM AND PILLAR WORK



<u>FIGURE 3</u> METHOD OF BALANCING PRESSURES ON STOPPINGS BY PRESSURE EQUALIZING ROADS AND DUCTS.

erecting a wall a short distance outbye the stopping - say 10 to 20 ft. away, and arranging means for raising or lowering the pressure of air in the chamber so constructed. The pressure in the chamber is controlled by means of a compressed air ejector or injector or by an auxiliary fan. Methods of doing this are shown in Figs. 4a and 4b. A more detailed illustration of a pressure chamber of the kind we use in our gassy seams is shown in Fig. 5.

The methods I have described for balancing the ventilation pressures on stoppings are effective both for preventing fires starting in worked out areas and in producing an inert atmosphere to extinguish a fire which has been sealed off. If the pressures have been balanced properly the effect is the same as if it had been possible to fill the area with inert gases. We have tried from time to time to put out fires in sealed off districts by introducing inert gases such as carbon dioxide or nitrogen. However, we have never been successful in extinguishing the fire completely in that way. Balancing the ventilation pressures has certainly proved to be a much more effective and practicable method.

DETECTION OF SPONTANEOUS COMBUSTION

In some cases spontaneous combustion can be detected in its early stages by means of sweating of the strata or by haze or by the characteristic smell associated with spontaneous combustion known as "gob stink". In other cases it can be detected in its early stages by an increase in the warmth of the strata. These methods are still available to us and still prove valuable but they are now complementary to the other more scientific methods based on air analysis and monitoring of the air.

In 1920 Ivor Graham showed that the amount of carbon monoxide evolved in relation to oxygen absorbed varied with the temperature of oxidation of coal and also with the time of exposure to oxidation and this method of interpreting the analyses of air samples has proved of immense value to the mining industry by enabling heatings to be detected in their early stages.

In more recent times we have had available to us automatic means of monitoring the air for carbon monoxide using the UNOR infra-red analyser. We can install the UNOR analyser at a point underground and record the percentage of carbon monoxide there or telemeter the results to some other convenient point underground or on the surface. Another way, which is the method we have found most suitable for our conditions, has been to install lengths of tube from the sampling points to the surface and to analyse the atmosphere drawn through these by means of the normal laboratory analytical apparatus or by using the UNOR. This method is known as the tube bundle system. The tube bundles are similar in appearance to small diameter multi-core electric cables. They are taken down the shaft, laid along the roadways and coupled together by junction boxes. A pump on the surface draws air continuously from all sampling points and by switching from one tube to another on the surface the air from each point can be analysed in turn.

The time taken for the air to be sucked from the sampling point to the analyser instrument on the surface through tubes 4 or 6 mm in diameter is not a serious matter when detecting for spontaneous combustion. This is so because spontaneous combustion normally has a relatively long incubation period. Though this may be as short as a few hours it is

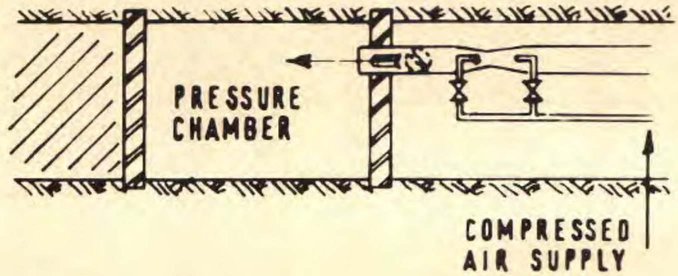


FIGURE 4(a) LAYOUT OF VENTURI INJECTORS FOR CONTROLLING CHAMBER AIR PRESSURE

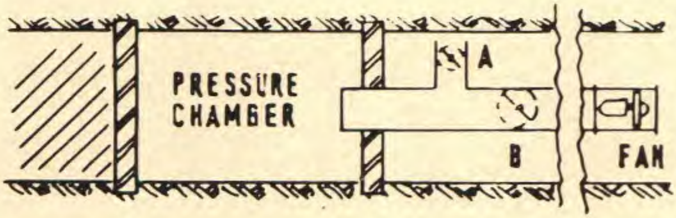


FIGURE 4(b) LAYOUT OF AUXILIARY FAN FOR CONTROLLING PRESSURE CHAMBER AIR PRESSURE

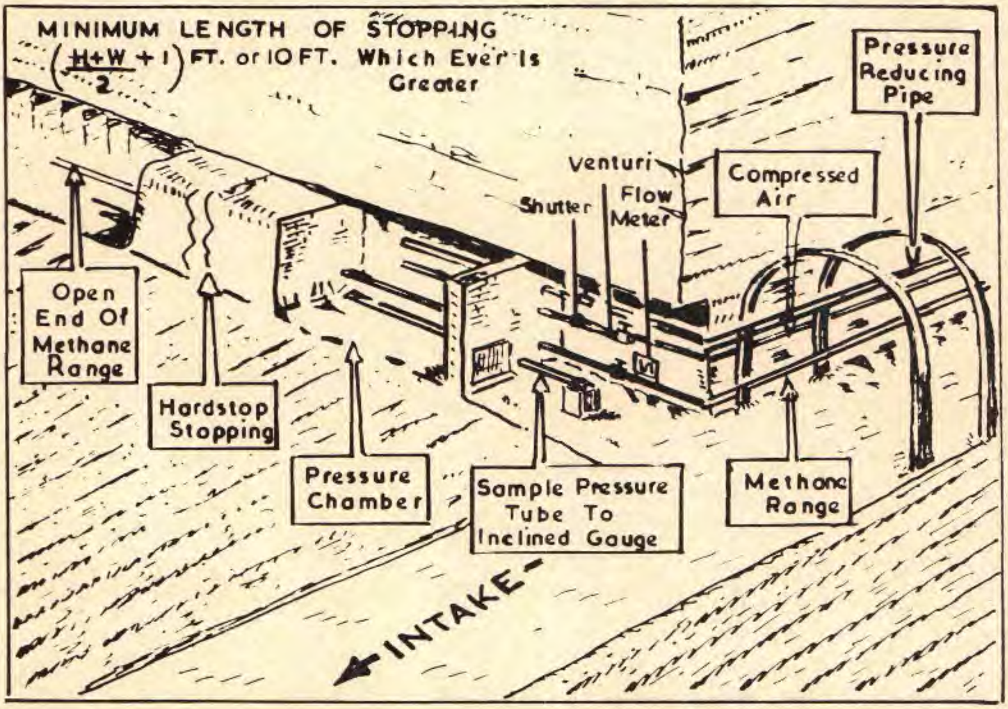


FIGURE 5 LAYOUT OF A STANDARD PRESSURE CONTROL STOPPING

usually several weeks. It is commonly 8 to 12 weeks in longwall workings. Thus an hour or possibly two hours delay in getting the results of samples for the detection of heatings due to spontaneous combustion is not a serious matter.

DETECTION OF OPEN FIRES

Open fires can occur very suddenly and therefore call for quick detection for which long tube bundle systems may not be quick enough. There is therefore need for a reliable automatic fire detector which can be positioned at strategic points underground to give virtually instantaneous warning of any abnormal conditions.

Instruments currently in use in British mines for this purpose are the Minerva smoke detector and the fusible link type. Experience has shown that the smoke detector has two serious limitations for underground use. Firstly, high humidity adversely affects the reliability of the instrument and, secondly, in dusty environments a false alarm is often given because the dust appears to have a similar effect to smoke.

The fusible link type detector is operated by the heat from the fire. It melts at 135° to 140°F and, in turn, automatically operates a sprinkler system of alarm. This has the disadvantage of not coming into operation until the fire has actually started but it has the potential advantage of speedily applying means to bring the fire under control depending on the positioning of the fusible detector and the means of extinguishing the fire.

A very recent development in Britain for detecting either spontaneous combustion or open fires has been the shaft air monitor which measures the carbon monoxide concentrations in the downcast and upcast shafts and operates an alarm in the event of any abnormal build-up in the carbon monoxide content in the mine. The instrument has a sensitivity of two parts in 10 million and is intended mainly for weekend use when no men are underground.

After an increase in carbon monoxide concentration or an increase in the CO/O_2 ratio has been detected by monitoring the air current or by air samples and analysis, we often find it desirable to investigate the source of the increase in carbon monoxide by using carbon monoxide detector tubes. A certain volume of air is drawn through the tube at a fixed rate by means of a special pump or aspirator and the length of the stain (or the change in colour) depending on the type of tube used, is a measure of the carbon monoxide content in the air. We mostly use the type of tube in which the length of the stain is measured rather than the colour because this has proved to be more accurate. Even so, it is important to have in mind that the tubes, as we use them, are complementary to the analytical and monitoring methods of detecting incipient heatings and are not considered by us to be accurate enough for the initial detection. We also arrange for members of rescue teams wearing self-contained breathing apparatus to use carbon monoxide detector tubes for the purpose of determining whether the composition of the atmosphere is suitable as a fresh air base or for working without the need to use self-contained breathing apparatus.

COMBATTING OPEN FIRES

The methods adopted for fighting an open type fire underground should depend upon the materials involved or likely to be involved in the fire.

If the fire has spread to timber, water from the fire hoses appears to be the best means of cooling down the timber. Water also is most suitable for small mechanical friction type fires such as those involving conveyor idler rollers and even for dealing with small quantities of grease and coal dust associated with such fires.

Serious fires can result from the ignition of inflammable fluids such as mineral oils. Our experience is that such fires when small can be smothered by means of a dry powder (sodium carbonate) type of extinguisher or by means of the foam or carbon dioxide type of hand extinguisher. But in the case of a severe fire involving mineral oil we have found the use of protein type foam to be the best method. The equipment is kept at strategic positions underground such as on the intake side of the main points of fire risk. The equipment comprises essentially, the foam making compound in a container and a special foam making branch pipe, incorporating a dip tube with an air inlet, which when foam is required to be made, is pushed into the container containing the compound. The inlet end of the branch pipe is connected to a water hydrant and the water flow siphons out the foaming compound and induces some air to produce a suitable foam.

In our gassy coal seams in Britain we have had a number of ignitions of small quantities of firedamp due to frictional sparking by the picks of the power loading machines. Most of these have extinguished themselves due to the quality of the ventilation, but when it has been necessary to apply an extinguishing agent, we have found it best to use the dry powder type of extinguisher or to use the water from the dust suppression system.

Obviously water must not be used on electrical fires. We use dry powder or carbon dioxide extinguishers for this purpose.

COMBATTING SPONTANEOUS COMBUSTION

The method adopted for dealing with spontaneous combustion once it has occurred must depend upon the position and intensity of the heating, the likelihood of accumulation of inflammable gas and the accessibility of the heating from the point of view of ventilation and treatment.

Under no circumstances should any change be made to the ventilation which would result in an increase in leakage through the heating area. In some cases, however, it is possible to reduce with advantage the quantity of ventilation passing along the roadways in the vicinity of the heating or to reduce the ventilation pressure difference across the heating area. In fact, I have had experience of keeping heatings under control by the equalisation of the ventilation pressures without the need to adopt any additional means. However, when a heating has occurred either in the goaf of a longwall district or in a coal pillar it is usually best to line the periphery of the roadways with an incombustible sealant in order to prevent access of air to the heating itself. Often it is necessary also to bore holes through the lining and to inject inert material to ensure that leakage is prevented sufficiently to extinguish the heating.

In the old days we tended to try to dig out the fire when spontaneous combustion occurred near the side of a road but it is now generally understood that in more cases than not this method tended to cause the fire to spread rather than to ensure complete success in the treatment of the heating. It is for this reason that the method of treatment we now adopt is to line the periphery of the road as I have just mentioned.

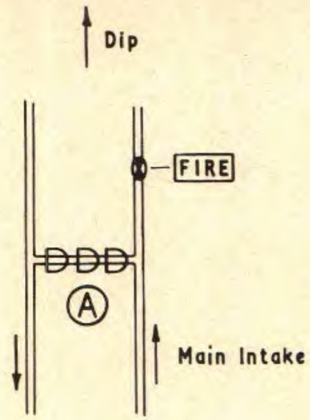
In the case of some fires in the goaf of longwall advancing workings we have obtained benefit in keeping a deep-seated heating under control by injecting bentonite which is a naturally occurring mineral clay which swells to many times its own volume when mixed with water.

EFFECTS OF A FIRE

It is now proposed to consider a practical approach to some examples of fire situations which could be encountered underground. The first point to appreciate is that a mine fire affecting inclined roadways can be likened to the introduction of a booster fan into the circuit which will assist the ventilation in rising roadways and oppose it in dipping roadways. Second, it is necessary to be able to assess whether the pressure generated by the fire will be low or high; this depends on the intensity of the fire and the gradients nvolved; for example, a severe fire at the bottom of a vertical roadway (such as staple shaft) will generate a high pressure whereas the effect would be small if the roadway was almost level. Third, the magnitude of the pressure generated by the fire needs to be assessed in relation to the magnitude and distribution of the normal ventilating pressure, for example, if the pressure generated by the fire is large relative to the available ventilation pressure, a fire would have profound effect on the stability of the ventilation - this is much more likely when a fire occurs near to or at the inbye end of the mine. Figure 6 illustrates two situations.

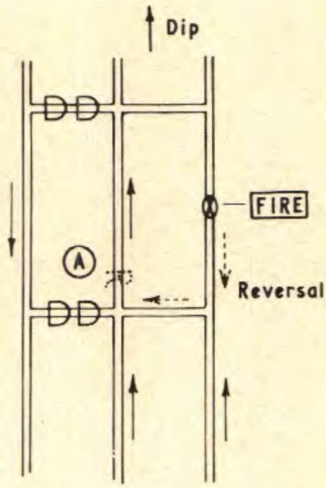
The first is a severe fire in a main intake dipping roadway. The pressure developed by the fire will tend to oppose the ventilation but, assuming that the available ventilation pressure is sufficient to overcome the buoyancy effect, there will be a reduction but no reversal in the fire area. If, for example, the pressure across the doors was high and the buoyancy pressure low, there would only be a comparatively small reduction in the ventilation flowing over the fire and no possibility of reversal. In no circumstances should the main fan be stopped or the doors (at A) opened wide or there would be a serious risk of a reversal. Only when the main air flow is high and the ventilation difference across the doors is high can consideration be given to regulating the doors to reduce the air flow through the fire. If the roadway had been rising instead of dipping, the air flow would increase through the fire and should always be regulated down.

The second case shows a fire in one of two parallel dipping and inter-connected roadways. There are a number of possibilities depending on the gradients of the roadway, severity of the fire and the total amount and distribution of ventilation in the two intakes. The effect of the fire would be first to reduce the quantity of air flowing through it - this would not be a bad thing so long as there was no danger of reversal and the smoke backing against the ventilation was not impeding fire fighting. A reversal would make fire fighting impossible, and, if there was any indication that this was likely to occur, the ventilation should be restricted in the



1.

Note: Risk of reversal if,
a) Doors 'A' scaled
b) Main fan stopped



2.

Note: Danger of reversal through fire area resulting in
a.) Increasing ventilation in adjacent intake
b.) Some recirculation of the fire gases

Action Install regulator at point 'A' to maintain stability of vent.

FIGURE 6 SEVERE FIRE IN A DIPPING ROADWAY second intake, that is, the erection of a regulator as shown on the slide. This example also indicates the problems which can be associated with inter-connected parallel roadways.

Figure 7 shows a fire in one of two descensionally ventilated faces. This fire would oppose and thereby reduce the ventilation through the fire and could result in a reversal of the ventilation round district A (with the consequent serious risk of an explosion) and recirculation round district B. The immediate ction is to regulate down district B with a view to stabilising the direction of the ventilation in district A.

Figure 8 shows the case of a fire in an ascensionally ventilated face. The fire would increase the ventilation in district A at the expense of district B, and could, in extreme circumstances, result in a reversal round district B. The action required is to regulate the ventilation in district A.

Figure 9 compares the effects of a severe open fire in a level road, a dipping road and a rising road.

EXPLOSIVE MIXTURES OF METHANE AND FIRE GASES

In considering the danger of explosion which might be caused by reversal over the fire of the mine air or fire gases, it is necessary to have in mind the limits of explosibility of methane and of gases produced by the fire. It is convenient to represent these limits in the form of triangles such as those shown in Figure 10. The triangle for methane is the one introduced by Dr. Coward some 50 years or so ago from which it will be clear that the lower limit of explosibility for methane is about 5 percent and the upper limit about 15 percent. Twelve percent of oxygen is necessary to make the mixture explosive at the lower explosive limit. It will be seen from Fig. 10 that the triangles drawn for hydrogen and carbon monoxide indicate a much wider range of explosibility for those two gases produced by fires. For example, the lower explosive limit of hydrogen is 4 percent and the upper limit is 75 percent. For carbon monoxide the lower explosive limit is 12.5 percent but the explosive range still extends to an upper limit of approximately 75 percent.

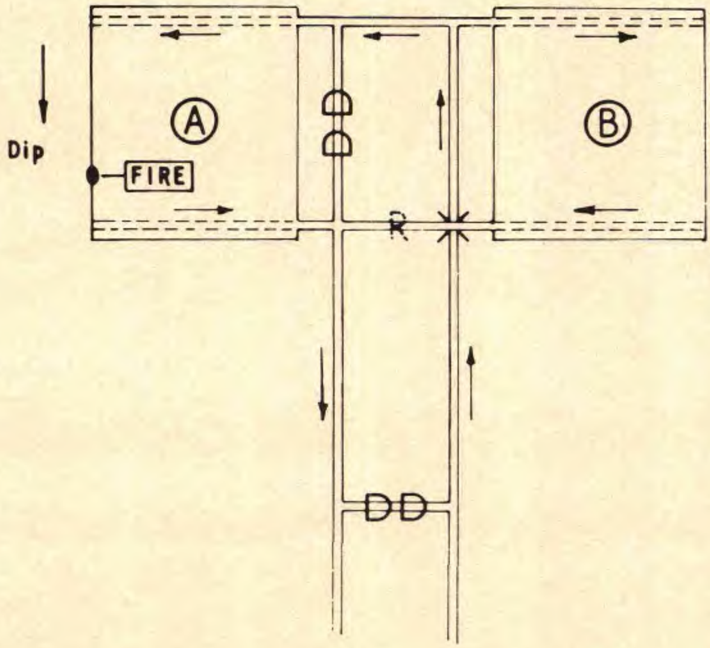
An important point to appreciate is that at the lower explosive limit the oxygen concentration need not be more than approximately 5 percent for hydrogen and 6 percent for carbon monoxide compared with approximately 12 percent for methane.

It will be appreciated from the above that a large and intense fire may produce explosive mixtures of fire gases irrespective of whether the mine is normally very gassy or not. Hence the importance of taking all necessary action to ensure that the fire gases are not allowed to reverse over the fire.

SEALING OFF THE FIRE

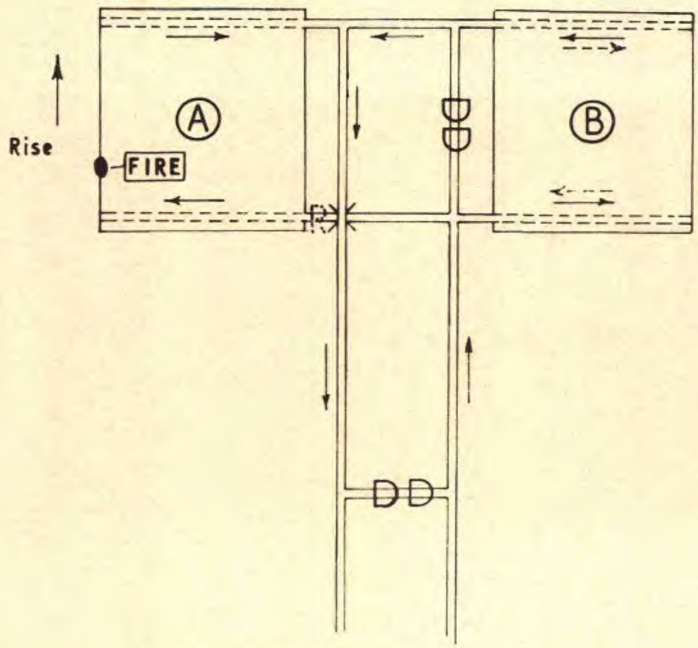
If the fire appears to be getting out of hand or there is evidence that an explosive mixture of gases might reach the fire, it is necessary to seal off the area by explosion-proof stoppings.

This raises three questions: the positions of the stoppings, the type of construction to make them explosion-proof, and the precautions to be taken to prevent an explosion while sealing off operations are in progress.



Note: Fire will reduce and possibly reverse ventilation in District (A) and increase ventilation in District (B) Regulators necessary in (B) to stabilise ventilation

FIGURE 7 FIRE ON DESCENSIONALLY VENTILATED FACE

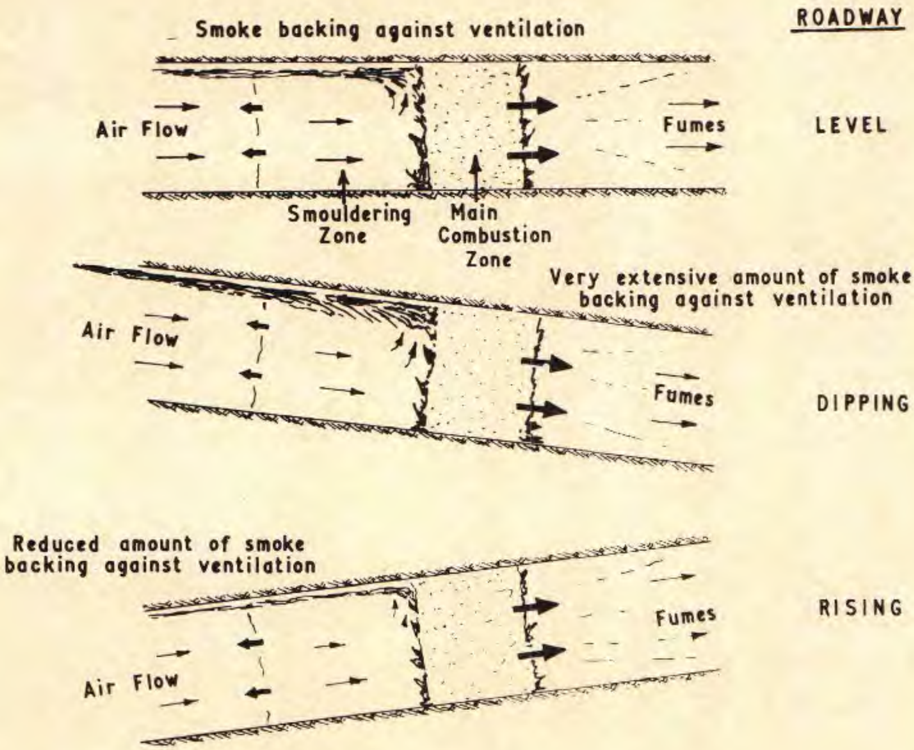


Note: Fire will increase quantity in District (A) with risk of possible reversal in District (B)

ACTION — Regulate on District (A)

Footnote: In all cases of severe fire in an ascensionally ventilated roadway, the procedure should be to regulate the flow through the fire down to at least the original quantity

FIGURE 8 FIRE ON ASCENSIONALLY VENTILATED FACE



1. Buoyancy Effect:
   a) Level road — negligible (assuming level downwind)
   b) Dip road — opposes ventilation
   c) Rise road — assists ventilation
   Amout of bu^yancy effect depends on temp. of fire and roadway inclination
2. Constriction Effect:
   Due to expansion of atmosphere in fire zone, its effect by itself is to reduce the ventilation in all cases
   The Reduction is related to —
   a) Original air quantity
   b) Fire temperature
   c) Ventilation system resistance

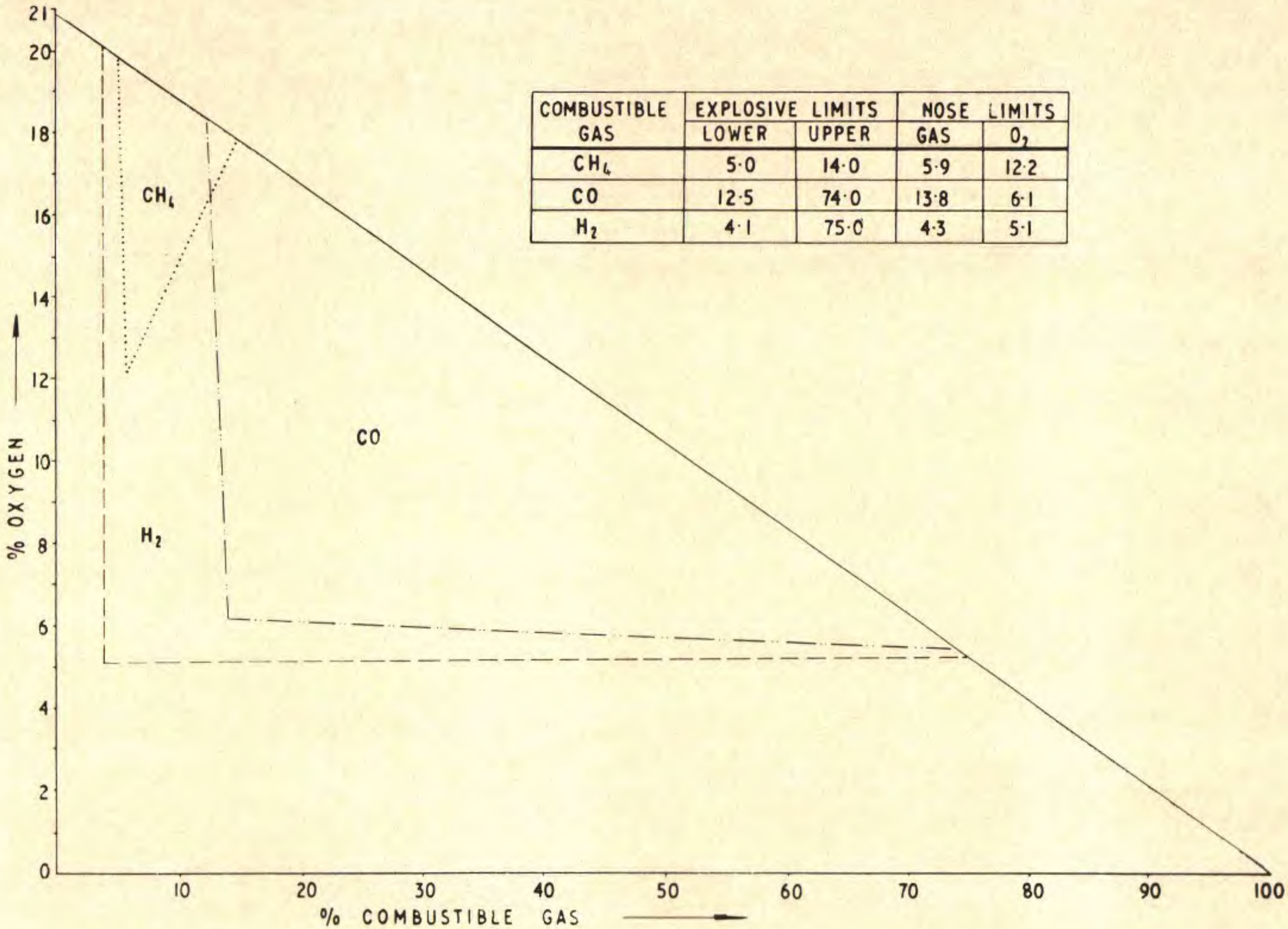
Notes:

With severe fires, the buoyancy effect is dominant in inclined roadways

a) Rise Roadway — Ventilation increased through fire
Danger of recirculation in inbye split

b) Dip Roadway — Ventilation reduced through fire
Danger of reversal through fire

FIGURE 9 SEVERE OPEN MINE FIRES



COMBUSTIBLE GAS	EXPLOSIVE LIMITS		NOSE LIMITS	
	LOWER	UPPER	GAS	O_2
CH_4	5·0	14·0	5·9	12·2
CO	12·5	74·0	13·8	6·1
H_2	4·1	75·0	4·3	5·1

FIGURE 10 EXPLOSIVE TRIANGLES

Firstly, it is necessary to consider the situation of the fire in relation to the position and volume of a possible explosive mixture of gases and then to consider whether an explosion started at the fire might develop into a coal dust explosion. The aim is to try and ensure that the men constructing the stoppings are beyond the range of projected flame and of blast of sufficient volume to injure them. This aim is usually achieved by the wise precaution, in such a case, of siting the stoppings several hundred yards back from the fire. Each case must be considered on its merits.

It cannot be assured that any practicable stopping will be proof against the most violent explosions which could conceivably occur. However, conditions giving rise to such very violent explosions, such as the presence of a volume of gas/air mixture of high inflammability, or of a potential cloud of nearly pure coal dust, extending over a large part of the sealed off roadways, are not to be expected. The kind of explosions most likely to occur within the sealed area are of limited volumes of gas in the vicinity either of the original fire or of residual fires.

In Britain we have generally had in mind that it would not be necessary for an explosion to withstand pressures of more than about 50 lbs/sq. in. for example, a total pressure of about 200 tons on a stopping built in a cross-sectional area of 60 sq.ft. This basis for design has proved satisfactory.

The traditional type of stoppings built for this purpose in Britain has been one of sandbags incorporating reinforcing materials. In more recent years, however, we have obtained excellent results by building stoppings of Hardstem (gypsum) by mechanised means. We have found that stoppings built of this material which are of a length equivalent to the average of the height of the road and the width of the road provide a stopping of the explosion-proof characteristics referred to above.

The prevention of an explosion during the sealing operations is achieved by incorporating in each stopping, as it is being built, a tunnel, or equivalent, which will allow sufficient ventilation to circulate over the fire to dilute inflammable gas to a safe percentage or to prevent any dangerous accumulations. When steel tubes are used we find it necessary for these to be of the order of 2 ft. 6 in. in diameter or more and where tunnels are used the cross-section is usually of the order of 3 ft. by 3 ft.

It is important to make arrangements to ensure that the tube or tunnel can be closed as quickly as possible at the desired moment once the stopping is completed. This is nowadays done by providing a stout steel door and housing at the inbye end of the tunnel or tube and by fitting a flange to the outbye end of the tube or by filling the tunnel with sandbags when that method is adopted.

It is necessary to seal all the stoppings simultaneously and then to withdraw all the men for a certain period until danger of explosion is thought to be passed. We have worked on the assumption that the waiting period during which no men are allowed to return to the stoppings should be of the order of 24 hours and this has worked very well.

CONCLUDING REMARKS

During my extensive tour of Queensland

last week I saw and heard at first hand some of the main problems that confront you so far as fires are concerned. In my address at the outset of this Seminar I have therefore tried to give you information and to raise points for discussion which might be helpful to you in solving some special problems in your particular conditions. For those reasons it was not possible to read a pre-prepared paper. I hope, however, I have said enough to stimulate further discussion today.

MINE FIRES SEMINAR

DISCUSSION SESSION FOLLOWING MAIN ADDRESS

Question regarding Frictional Ignitions

Dr. Willett. The whole of the 111 ignitions that I have referred to have been frictional ignitions at coal face power loaders caused by the picks striking quartz or iron pyrites. We have found that the best way of preventing these is to use what we call a hollow shaft ventilator. This consists essentially of a hollow drum shaft with a water jet which induces a flow of air to the vicinity of the revolving picks. Strata containing over 50% quartz has a high incendive temperature potential. Strata containing 30% to 50% quartz has a medium incendive potential and strata with less than 30% quartz has a negligible incendive temperature potential.

Question regarding reversal of ventilation

Dr. Willett. A decision to reverse the ventilation in a mine is a very serious decision and one that should only be taken after very careful consideration of all the circumstances. Reversal of the ventilation is desirable in some cases and unsafe in others. For that reason each individual case must be taken on its merits. The main danger of reversal of ventilation is in gassy mines and the possibility of reversing firedamp over a fire and causing an explosion. In some cases reversal has been advantageous. One such example was a few years ago when we had a fire in a cable duct at the top of the downcast shaft at one of our mines. There had been a flash from a damaged electric cable which had set fire to some mineral oil and this in turn had set fire to wood near the top of the shaft. Within a few minutes the fumes were travelling down the downcast shaft and along the intake roadway towards the workmen. The reversal arrangements were put into operation promptly and as a result the men were withdrawn from the mine in safety via the upcast shaft. One lesson we did learn from this incident was the importance of periodically checking that the reversal arrangements can be put into operation very quickly. Unless they can be put into operation very quickly reversal of the ventilation may take too long to be of value when required.

Question regarding the separation of main intake airways by doors or stoppings

Dr. Willett. When there is more than one intake airway with connections between them the fumes from a fire in one intake airway may spread to the other and prevent it from being a suitable escape route for men. The roads could be isolated by erecting stoppings or doors in the connecting slits. Stoppings are suitable where the connecting road is not needed in an emergency but in connecting roads which are needed either for an emergency or for the supply of materials I would use doors. One has to remember, however, that there may be occasions when the air will travel one way along the connecting road and other occasions when it will travel in the opposite direction. For that reason latches or some other arrangement may be necessary to keep the doors in the closed position.

Question regarding the use of the Foam-Plug Method of fighting fires underground

Dr. Willett. When trials were carried out with the foam-plug method in Britain some 20 years or so ago we had great hopes that this method would prove an effective means of extinguishing fires in safety from a remote position. However, the experience gained in the course of the trials indicated the limitations of the method. There was no difficulty in producing a foam-plug by spraying a liquid foam agent on to a net erected across the roadway through which the ventilation passed. But difficulties arose in movement of the foam-plug along gradients and in air velocities of the kind which could be expected in mines. For example, foam-plugs could not be made to fill and travel in roadways where the inclination was greater than 1 in 5 downwards and in rising gradients greater than about 1 in 10 there was difficulty in moving the foam plug at a sufficient rate with the ventilation pressure normally available in mines. The method certainly proved effective in trials in level roadways but because of the varying gradients and air velocities in our mines we did not pursue the use of the foam-plug method on a national scale. There was the further point that where explosive gas may be present in the vicinity of the fire, the foam-lug method may increase the risk of a firedamp explosion. However, the Americans still have faith in the method and further research and development is being pursued by them.

Question regarding the monitoring of gases in the air for the detection of spontaneous combustion

Dr. Willett. We monitor carbon monoxide gas, that is the main gas given off by a fire and by spontaneous combustion. The most suitable analytical instrument available at the moment for carbon monoxide is the UNOR infra-red analyser. There are two methods of applying the principles of continuous monitoring: either the tube bundle system may be used and the samples analysed on the surface or the UNOR can be sited underground and the results telemetered to the surface. A very recent development has been the shaft air monitor which measures the carbon monoxide concentration in the downcast and upcast shafts (about 50 ft. down) and operates an alarm in the event of any abnormal build-up in the carbon monoxide content between the two points of measurement. The instrument has a sensitivity of 2 parts in 10 million. It is very useful for weekends when there are no men underground.

Question regarding cost of monitoring carbon monoxide at a relatively small mine and the interest shown in the results

Dr. Willett. The total cost of the UNOR instrument and the tubing and ancillary apparatus cost someting of the order of £1500 for an installation where the length of tubing required is not very great. The potential advantages of the system are well worth the cost incurred and the mine officials take a great interest in the results and in the "kinks" in the graph due to shotfiring and the use of diesel locomotives. It could be an easy matter to separate these peaks and humps from the steady background level of normality which exists until there is a gradual rise due to spontaneous combustion.

Question regarding the sealing of gassy workings. How long does it take to erect the kind of seal which was referred to? Would there be a simpler method of sealing?

Dr. Willett. We work on the assumption in Britain that there may be an explosion behind the stoppings after sealing off which could develop a pressure of up to 50 lbs/sq. in. The traditional method of building such an explosion-proof stopping has been to use sandbags and steel reinforcement. In the size of roadways which I have seen in mines in Australia, for example, about 20 ft. wide and 10 ft. high, a stopping built of sandbags and steel reinforcement would have to be something of the order of 30 ft. in length for it to be explosion-proof. In recent years we have developed a means of building stoppings by using gypsum (the trade name is Hardstop or Hardstem) and this material can be pumped from a remote point up to several hundred yards away. Experience has shown that such a stopping can be built much more quickly than a sandbag type of stopping and that in the size of road I have referred to it would only be necessary to make the stopping 15 ft. in length for it to be expolosion-proof. Because the material can be pumped from a remote point the persons engaged in this work can be protected more easily from fumes and smoke and possible explosion. We have built gypsum stoppings in roads of large cross-sectional area in approximately 10 hours which is, of course, much shorter than the time required for building the traditional type of stopping. When sealing off a gassy district it is necessary, of course, to leave a ventilation road through the stopping, either a tube or a tunnel, irrespective of the type of stopping being built. This tube or tunnel is not filled in but at a pre-determined time when the stoppings are completed, an explosion-proof door is closed at the inbye end of the tube or tunnel and a flange or steel door is closed at the outer end of the tube or tunnel. Men are withdrawn from the district in which the stoppings are situated for approximately 24 hours to cover the period during which it is thought that the atmosphere might pass through the explosive range.

Question - Would you elaborate a little further on that answer? Presumably when you started these seals the fire had reached an uncontrollable stage. Would you contemplate at any time erecting a type of seal other than an explosion-proof type to seal off the area quickly?

Dr. Willett. If there is a fire in a gassy district I would not erect any type of seal other than an explosion-proof one despite the fact that it could be built more quickly. My experience is that it is a most dangerous thing to do because the men who subsequently extend that stopping to make it explosion-proof or build an explosion-proof stopping some distance outbye would be exposed to danger during the period when the gases in the sealed area might be passing through the explosive range. In fact, this is what happened in one of the actual cases I described in the early part of my talk.

Question regarding the use of stone dust and water in order to prevent the propagation of an explosion.

Dr. Willett. The minimum amount of fine coal dust which can propagate an explosion is very small - something of the order of 1/40th oz. of coal dust per cubic foot of an underground road - which could be obtained in such a road by a layer of dust on the roof, floor and sides no thicker than a piece of paper. Watering the roads was considered to be the best way of preventing coal dust explosions until about 50 years ago, when research established that the application of fine incombustible dust provided better protection. The treatment in this way of all roads in coal mines in Britain (except anthracite mines which were not considered liable to coal dust explosions) was made the subject of general regulations in 1920. For a coal dust explosion to take place, the dust must first be raised into the air and ignited, and this combination of circumstances is unlikely to happen in a mine except through the agency of a firedamp explosion. If sufficient inert dust is present in the air it can make the dust cloud non-inflammable. This is the principle behind general stone dusting which aims to prevent the development of a possible coal dust explosion by ensuring that the dust cloud raised by a firedamp explosion will contain a sufficiently high proportion of inert dust. However, an explosion at Six Bells Colliery in Monmouthshire in 1960 indicated that sufficient coal dust may be present on the conveyor belt and structure in a coal conveyor road to be capable of propagating an explosion even if the amount of stone dust applied to the roof, floor and sides of the road is deemed to be sufficient. In that case the explosion was propagated along conveyor roadways for several thousand yards. With the help and advice of the British Safety in Mines Research Establishment and of Dr. Cybulski of Poland, we came to the conclusion that in addition to general stone dusting we must also install stone dust barriers in coal conveyor roads. These are now installed at all mines of the National Coal Board other than those where the coal is anthracite which is not considered to be explosive. The stone dust barriers are erected in the length of roadway between 70 yards and 130 yards from the coal face and in the length of road between 200 and 350 yards of the coal face. The stone dust barriers consist of a number of wooden shelves loaded with stone dust which are designed and placed so as to be disrupted by the blast which travels some distance ahead of the flame of an explosion, thus creating a dense cloud of stone dust in the air just before the flame of the explosion arrives. The type of shelf we use consists of a large number of short boards resting loosely on, and at right angles to, a rigid frame placed across the road near the roof and supported freely on brackets fixed at each side of the road. This type of barrier has only been required to operate on two occasions in mines in Britain and on both occasions where they were installed they quenched the flame of the explosion. Now just a word on water barriers. Research in Britain and in Germany has shown that a water barrier is at least as effective as a stone dust barrier. We have found, however, that water barriers have two practical difficulties. One is that the type of container for the water requires more height than a stone dust barrier and this can be quite a hindrance in some underground roadways. The second difficulty which it is hoped will be overcome fully by improved types of troughs and lids is that of evaporation of the water. Bearing in mind that we have been highly satisfied with stone dust barriers, we are awaiting the results of further research and experience before considering whether to change over from stone dust barriers to water barriers. We are, however, hopeful that a trigger type of barrier will soon become available for use particularly in some of our headings in thin seams where there is insufficient height for a stone dust barrier. The advantage of the triggered barrier is that the disperser for the inert cloud, whether it be of water or a powder, does not take up much room in the roadway and is situated some distance from the thermal relay which operates the disperser in the event of an explosion.

Question regarding mist and water spray barriers

Dr. Willett. Mist and water sprays are being tried in the gallery experiments in Britain with triggered barriers. It is considered that the water sprays may be adequate to stop an explosion. We do, however, have a number of mist and water sprays sited with the aim of trying to prevent the spread of fire. They are intended to operate by fusible plugs at temperatures of the order of 130° to $140^{\circ}F$. It depends, of course, on the siting of the fusible plugs in relation to the subsequent fire as to how soon and whether the water can extinguish or prevent the further spread of the fire. We are not keen to install continuously operated water sprays discharging large quantities of water into the intake airways on account of the humidity problem in some of our deeper mines.

Question regarding the period of 24 hours after sealing a section. Could you tell me why you leave it for 24 hours, why not 12, why not 48?

Dr. Willett. When we wrote a Memorandum on Sealing off Fires Underground for the Institution of Mining Engineers in 1962 we wanted to give some general guidance to managements on this point. The collective experience of those of us on the Committee indicated that when there was a fire in a very gassy district the explosive range was passed through within a few hours of sealing. In fairly gassy districts it took a few hours longer than this. The analytical information obtained from stoppings after sealing tended to indicate that if the explosive range was not passed through within a whole day and night, it was likely that the oxygen content would be reduced to a safe level before gas built up to a dangerous level. Taking all this experience and analytical information together, we decided on 24 hours as a general figure which would not lead to danger. I accept that there will be many cases when the danger is over long before this period has elapsed. Much will depend on the effectiveness of the pressure balancing on the stoppings.

Question regarding the organisation which the National Coal Board puts into a major incident such as a fire?

Dr. Willett. We have 26 Rescue Stations strategically placed throughout the country; 250 full-time rescue men and nearly 3000 fully trained resuce men who are workmen at collieries. In the event of a serious fire the first thing that is done is a telephone call from the colliery to the Rescue Station which leads to the prompt arrival at the mine of rescue apparatus and the necessary men to wear it. In addition to that we have what is known as an emergency organisation so far as officials are concerned. Our coal mines are grouped by Areas with various mining officials senior to the colliery manager. These officials are telephoned for and take part in the planning and control of the operation. We also have an organisation whereby our Medical Doctors turn out immediately to examine the rescue men and the scientists arrange for the transportation of one of the portable laboratories to the mine concerned. In each coalfield we have a District Rescue Stations Manager who is called out immediately after the Rescue Station turns out. He then calls out the General Manager of Rescue Stations and by that time, when the incident is a really serious one, I have received a telephone call direct from the mine or the Area and have left by car or train or plane to the mine concerned.

Question - Who accepts the ultimate responsibility?

Dr. Willett. When it is a very serious fire involving decisions which are not fairly obvious and which have to take into account many ramifications, the ultimate responsibility for the decision rests on me.

Questions regarding the course of the travel of the explosion at Six Bells Colliery. Was it a single road? What were the dimensions? Was the coal normally dry?

Dr. Willett. The main spread of the explosion was along a single road. The flame extended for approximately 1000 yards on each side of the point of ignition. The dimensions of the lengths of road involved were of the order of 100 square feet in area, the supports being steel arched girders, the method of working was longwall advancing, the roadways were dry. The inclination was about 1 in 20. Investigations showed that the coal dust explosion had been initiated by the ignition of approximately 150 cubic feet of firedamp by an incendive spark caused by the impact of a quartzitic stone falling from the roadway roof near the face ripping lip on to a steel canopy provided to protect the roadway conveyor during blasting operations. Analyses of samples of roadway dust after the explosion showed quite clearly that the stone dust requirements so far as the roof, floor and sides of the roadway were concerned were fully complied with. The additional factor, as I have already mentioned, was the coal dust on the conveyor and on the structure of the conveyor which in our view was raised into a cloud by the initial firedamp explosion and produced an extensive coal dust explosion. I would like to make it clear that the normal method of stone dusting the roof, floor and sides of a roadway is quite adequate to prevent a coal dust explosion in a roadway in which there is no coal conveyor. We are satisfied that it is only in coal conveyor roads that we need the additional precaution of stone dust barriers or water barriers or triggered barriers. The upshot of this, coming back to the question, is that in my view it is not necessary to install stone dust barriers in your inter-connected roadways except the roads in which there are conveyors. In other roads however inter-connected they may be, the normal stone dusting remedy should be sufficient to prevent danger provided the stone dusting is done regularly and samples are taken to monitor the conditions.

Question regarding the slowing down of fans and ventilation over fires. Would you kindly explain the difference or the distinction between using regulators and actually reducing the speed of the fan?

Dr. Willett. The advice I would give in all circumstances is do not stop the fan completely because this would allow the situation to get out of control. One of the effects would be that smoke would create difficulties and gases might back over the fire. The other advice I would give would have to depend upon the situation of the fire and its intensity. The principle to have in mind is that there must be no recirculation and gases must not be allowed back over the fire. There are many ways of dealing with such a situation but the particular method will have to be based on the actual circumstances in each case. For example, in some cases it may be best to increase the resistance in the fan drift by partly closing louvre doors. In other cases, or in addition, it might be best to open doors in the surface air lock giving the fan direct access to the atmosphere. In other circumstances it may be best to open appropriate doors underground. I am afraid this is a matter on which I cannot give a more specific general answer. Perhaps you will consider what I have just said in conjunction with what I said earlier with the aid of the illustrations.

MINE FIRES SEMINAR - REPORT OF DISCUSSION GROUP I

"PREVENTION AND TREATMENT OF MINE FIRES OTHER THAN THOSE CAUSED BY SPONTANEOUS COMBUSTION"

Mr. Chairman, Dr. Willett, Miss Jacka, Gentlemen,

Group 1 had the subject of prevention and treatment of Mine Fires other than those caused by spontaneous combustion. In order to commence the discussion the Group thought it would be desirable to determine the major causes of fires. The causes listed were conveyor belts, electric cable and control equipment, machines which use oil, covering diesel and hydraulic. Having stated these causes the Group then agreed that they were not the causes of major fires. Notwithstanding the Group appreciated the need of prevention of fires from these causes.

After discussion of several major fires in recent years, the conclusion was reached that they were all associated with gas. Examples were Appin, Nymboida, Bulli and Sirius Creek. The significant aspects of these fires was that the source of the gas was not at the working face but was due to accumulation of gas in other areas.

Having cleared this point the Group then considered the prevention of mine fires.

As gas accumulations were regarded as the cause of major fires the Group concluded that for prevention there had to be adequate ventilation through the mine. In addition the gas detection equipment had to be of first class order and gas detection had to take place at regular intervals. Also the problems of layering of gas had to be always borne in mind. The education of all personnel underground was essential to emphasise awareness in addition to prevention procedures and action to take to quell any outbreak of fire. Amongst prevention requirements it was considered most important that the proper mining practices be understood. Again and again in the discussion the need to know the quality and reliability of the testing equipment was emphasised. Cases were mentioned where it was discovered that a methanometer was completely out of order and yet it was being accepted as a reliable instrument.

Regular inspections were the most important means of fire prevention. The need for regular inspections of conveyors was emphasised. Regular inspections reduced the time the fire had to develop.

Proper maintenance and general housekeeping and cleanliness appeared to be the most important aspects of prevention. In this regard particularly with the inspection of conveyors it was emphasised by the group that the selection of men with experience was essential.

In some collieries the checking of conveyor belts was done by the "new man". It was difficult for him to detect any faulty or failed equipment. You will appreciate that some of the inspections particularly in conveyor belts rely on hearing. Our group emphasised that a check was necessary on the hearing level of the men concerned. In N.S.W. we understand this is compulsory in some fields. The group also stated that they thought that notwithstanding that you have got an experienced man carrying out the inspections particularly the audial inspections that the "fresh ear" was a good idea every now and again. The subject was discussed also of mineral oil being reticulated by pipeline to underground operations as was mentioned by Dr. Willett this morning, and the group thought that the possible hazard of a major spillage outruled the advantages of handling of bulk product in this manner. This may not take long to relate to you but at this stage we ran out of time and we were unable to discuss the second part of the assignment which was the treatment of fires.

The Group expressed the opinion of the value of discussion in small groups which enabled all to participate.

MINE FIRES SEMINAR - REPORT OF DISCUSSION GROUP 2

"THE SEALING OFF OF FIRES UNDERGROUND"

Mr. Chairman, Dr. Willett, Miss Jacka, Gentlemen,

The task for Group 2 was to study the sealing off of fires underground and the first question discussed was "Who makes the decision to seal off?".

Opinions differed amongst the members so we decided to refer the matter to Dr. Willett and went on to discuss the types of fires that should be sealed.

It came back basically to two types: the spontaneous combustion fire that is in an area that is difficult to get at and so it is a matter of keeping air off it and letting it cool and die down. That is usually a fairly simple one to deal with.

Then there is the major fire; the one that is getting out of control and finally gets out of control, very often associated with the recirculation of the products of combustion. That is the difficult one to deal with. Having decided that it was out of control and required sealing, we then discussed the various positions in which we might locate the seals.

The considerations that we discussed were very much the same areas that Dr. Willett talked about; the availability of access for getting the materials into the job; good firm roofs so the seals would be substantial. However, our conditions are somewhat different from Dr. Willett's because where probably he hasn't got many more than two roadways to seal, we might have 3, 4, 15, 20. This does happen in bord and pillar sections and so probably our seals are not going to be like Dr. Willett's seals. Our seals are going to be more of the brick and mortar type of seal.

Another consideration to come out of our discussion is the fact that in our type of mining our main road stoppings are probably only 9 inches thick, anyway, so is it worthwhile putting in a good explosion proof seal when you've got another twenty, or more points of weakness that can blow out? So we talked more along the lines of sealing as we always have, and this is a point on which Dr. Willett might be critical.

We said, "What we do now is put up our normal type of seal, get out of the mine, cross our fingers, then go back later to see whether those seals have blown out or been ruptured or what has happened to them." This has been our history; whether it's wrong or not I don't know, but I think possibly it's not too far wrong, because in all the fires that have been sealed, this is what has been done. Maybe the seals have been blown out the first time but in the second, stood.

Then we talked about the type of seal we should build and we talked about the brick seal, the dry brick seal - that is, just bricks stacked on one another - you could put those in very quickly and plaster them over later. They don't make a bad seal as long as you don't get an explosion. All we are doing is sealing off to stop the ingress of oxygen into the area.

One member of our group described the Rigi-seal seal he uses and he has a very good reason for using it. He's got a 30 foot seam and if he builds a brick seal he's supporting a tremendous weight by the time he gets up to the roof. The Rigi-seal seal can be put up very quickly, it can be made quite airtight and it can do a very good job in sealing off to stop the oxygen getting into the fire. He also mentions the gunite seal, which is comprised of chicken wire, arch mesh, and brattice, with sand and cement slurry blown over it. They also can be quite effective; they were sealed to coal; they were sealed to the basic stopping and they would form quite a good seal.

We talked about timber seals; both those with wide planks laid flat on the floor and built up, with staggered joints, to the roof and those with tongue and groove timber nailed onto the framework. Both of these have been used and both have been quite effective.

One idea suggested seems quite sound; it was the placing of copious supplies of stone dust, loose, inside and outside the seal, so if there is an explosion it will have the chance of stirring the stone dust up and perhaps retarding it somewhat.

We also discussed the conditions under which sealing would take place; that there would be a minimum number of men in the mine at the time of sealing and the simultaneous closing of the intake and return seals that Dr. Willett described.

Then we got into a more general discussion and people described different incidents they had taken part in: maybe the first seal and the last seal were three quarters of a mile apart: maybe the area being sealed off was some square miles in area: of the number of seals or stoppings that would be needed to be repaired to keep the air out. All this seemed to confirm our thinking that very often, perhaps, the first thing to do is to seal for exclusion of air; see if it holds and then get back as quickly as you can and build something good and strong outside of it. We didn't reach a final conclusion on that, as our group was a little like group one, in that we didn't have enough time and I wouldn't be surprised if the other groups had the same problem.

One item that we did take time to discuss fairly fully was that of the organisation required to deal with a fire. We considered that this came into sealing because the organisation must decide when to seal; it must decide where to seal; it must decide the appliance that must be made available, such as the gas testers, etc., and it seemed to us that there was a lack of such an organisation in this State and in New South Wales.

The rescue station groups do a very fine job, but they do not have the authority to deal with these situations. The managements of the mines also do a good job and they do have the authority, but very often, particularly in Queensland they are fairly thinly spread in management personnel and it does seem that perhaps that some thought could be given to some form of organisation that could be called upon to come together at such a time to give assistance to the mine that is in trouble.

MINE FIRES SEMINAR - REPORT OF DISCUSSION GROUP 3

"TREATMENT OF SPONTANEOUS COMBUSTION"

Mr. Chairman, Dr. Willett, Miss Jacka, Gentlemen,

Group 3 were asked to discuss the treatment of spontaneous combustion.

Before discussing specific cases we agreed that certain preliminary information should be available. The following questions are typical of the information which might be requested:

1. Have workmen been withdrawn?
2. Have gas samples been taken?
3. Is the mine gassy?
4. What are the details of water supply?
5. Are mine plans available?
6. What equipment is available?

We discussed treatment in four different circumstances as follows:

1. Spontaneous combustion in shafts and shaft pillars.
2. Spontaneous combustion in roadway pillars.
3. Spontaneous combustion in falls in roadways.
4. Spontaneous combustion in goafs.

Shafts

In discussing shafts we agreed that spontaneous combustion was possible but unlikely. Heatings could occur in spillage material and in shaft pillars.

Downcast shafts would normally be subject to more frequent supervision if only because they are used for travelling and any heating would be of a minor nature. Spillage material could be covered with stonedust and loaded out. Heatings in the pillars could be dealt with by water injection and/or plastering and if necessary by digging out and loading the material away. It was considered that an upcast shaft could be the cause of a more severe problem because of the likelihood that there would not be such constant inspection and therefore that the fire may have developed to a greater extent. We spoke about the possibility of reducing the ventilation in the upcast shaft either by controlling the fan or restricting the total quantity in the mine. It was thought that reducing the air velocity would slow down the rate of spread of the spontaneous combustion. The material could be dug out, covered over and removed from the mine. We did not consider that there would be any danger in using the assistance of water to help to reduce the possibility of an outbreak of an open fire. In commenting that we could reduce the ventilation we made the point that we would want to know that the workings were not going to be unduly affected by any build-up of gas.

Roadway Pillars

Spontaneous combustion in roadway pillars was considered to be a major problem requiring special techniques.

Water or grout should be injected into the pillars and the surface carefully plastered to reduce leakage of air. Particular care would be required to plaster not only the pillar but also the floor and roof because of the likelihood of leakage of air over or under as well as through the coal.

In cases where the heating is well advanced before detection action should be taken during the sealing stages to reduce the leakage by lowering the water gauge pressure drop across the pillar.

Consideration could be given to installing a temperature measuring device in the pillar to monitor the stability of the pillar after completion of sealing.

Roadways

We considered two different circumstances, well ventilated and poorly ventilated roadways.

In well ventilated roadways any heating which occurs under a fall should be dealt with by stonedusting the fall and loading the material out as speedily as possible. It was considered that there would be no problem in using water to cool the heating if good ventilation was maintained. Comment was made that modern diesel powered equipment can be of great assistance in dealing with this type of problem because such equipment of the front end loader type is very mobile.

In poorly ventilated roadways stone dusting is the logical method of first treatment. Watering should be avoided but action should be taken to improve the ventilation. An increased flow of air in the area would have the effect of removing some of the heat from the material and would also make working conditions more comfortable.

Goafs

Heatings in goaf areas were regarded as the most serious problem. We did not deal with the special case of heatings in goafs associated with longwall advancing faces because the advancing system is not used in this country.

During the early stages of extraction in an area before a major fall has occurred it is possible to get a heating in coal lying on the floor in the goaf. The tendency to heat is accentuated by the flow of air across the goaf area. We considered that an incipient heating would be detected by monitoring and the action to be taken would depend largely on experience of the seam characteristics. If it was known that the heating would spread rapidly the only solution would be to seal the area. If it was known that the development of the heating would be slow then mining should be continued. The rate of extraction should be increased if possible to encourage an early major fall which might blanket and smother the heating and allow continuation of the extraction line.

As a face or pillar line retreats away from a goaf area and it becomes apparent that a heating is developing in the goaf there is no alternative than to seal off the goaf. It was emphasised that the seals should be erected speedily because the heating could develop rapidly and could result in the loss of valuable reserves. It was felt that experience in this country has shown that a simple light seal perhaps made of plaster board should be erected immediately and that this type of seal will allow the establishment of a new face line only a short distance outbye. There was some difference of opinion between members of the group at this point and a minority number preferred the use of brick seals up to 3'6" thick. It was pointed out that these seals give better explosion resistance and that the time of construction in an emergency can be reduced by ensuring beforehand that prepared footings are available.

In making general comments about the problem of spontaneous combustion the group emphasised the need for monitoring mine atmospheres to give early warning of the development of heatings. It was felt that control of the problem was largely a matter of forward planning, proper layout of the mine in terms of number of entries to panels, the size of panels and preparatory work so that stoppings can be erected speedily in an emergency.

MINE FIRES SEMINAR - REPORT OF DISCUSSION GROUP 4

"PREVENTION OF SPONTANEOUS COMBUSTION"

Mr. Chairman, Dr. Willett, Miss Jacka, Gentlemen,

Our particular subject is headed "Prevention of Spontaneous Combustion" and that of course must overlap some of the specific subjects of other groups. I think we began by deciding it was not possible to prevent spontaneous combustion and our thoughts therefore were related more to reducing the effects and controlling spontaneous combustion and losses from it. We did try to raise the subject of inhibitors, but we didn't have a chemist amongst us, so we didn't get very far on that subject. We did feel however that the answer to the basic question of prevention of spontaneous combustion was in proper planning.

This leaves us with two different situations. It is an entirely different case to start off with a new coal seam, a new area, new beginnings and new plans, than it is to take over an old mine which was extensively worked prior to any knowledge of the problem or possibility of spontaneous combustion and where the mines were worked in an economic situation which did not allow the developments and controls that we have today. We feel that the problem of layout of established mines, that is extraction of coal from pillars already formed over extensive areas such as Dr. Willett showed us, produces a need initially to sub-divide the area into smaller areas before any extraction commences. This can be done in a number of ways and we talked about various ways of doing it with seals and stowage. Basically we think we could reduce losses and obtain better control of the development of spontaneous combustion by beginning with smaller areas which we could remove in a certain predetermined time. This of course also applies to the case of opening up new seams or a new mine in established seams. We feel that a situation such as that mentioned by Dr. Willett, something like the one that is shown on the blackboard where extensive areas of pillars are formed before any attempt is made to extract them should never again be allowed to develop in any mine, let alone one that is liable to spontaneous combustion.

In determining methods of taking coal from a new area in a way to avoid as far as practicable the development of spontaneous combustion and losses from it, we opted basically I think for driving a couple of headings from the main roadway to a predetermined limit, forming pillars, and taking them out on a retreat method immediately they were formed. We would of course in driving those headings, take the necessary precautions for later sealing and we would have taken the necessary steps to see that our pillars were adequate in size and shape.

Having done all those things, what we felt was also necessary was a plan of action in anticipation of what might happen, and this was the responsibility of management, the responsibility of workmen, the responsibility of everybody in the industry to know where we go when something happens, to know what people and material were available in the mine, and in the mining district. In dealing with the problems of some of the older mines, we appreciated the possibility of pillar crush and once we recognise that there is a problem of spontaneous combustion we suggest that particularly on main road pillars and between intakes and returns we should not wait for some development of spontaneous combustion but inject some limestone and cement into these pillars before the problem develops. The question of use of carbon dioxide in its various forms was gain discussed. It was raised with Dr. Willett during our group discussion, and from the experience of those in the group who had tried it, we could only agree with Dr. Willett that it would show no lasting benefits. It did help to control a situation temporarily but that is all that could be said about it.

We got onto a discussion on the question of incubation periods. It was widely claimed that in any given circumstances, pillar extraction for example, a heating will develop after certain predetermined times when certain conditions have been fulfilled in relation to strata movement and other factors, and the only basis for determining the incubation period for a particular mine or a particular seam was experience in that area. This is fine and it gives some help perhaps to a person who has an old mine in an area where experience is available, but how about the new seam we've just discovered, say two hundred miles west of Mount Isa or somewhere where there is no previous experience. A poor fellow goes there, he's trying to design the mine, do the right thing technically, and he also has to think of the economics. He knows there may be some liability to spontaneous combustion, we have no way of knowing the extent of this, no way of advising him of the size of panels he should adopt and no experience with incubation periods. There was considerable difference of opinion as to the reliability of the incubation time before the effects of spontaneous combustion became serious. If it can be accepted that there is such a period, experience can determine a design such that you take all the coal you can possibly get from that part of the seam before such a time arrives.

In discussing this matter, the group appreciated the fact that we were perhaps talking, should I say the word, as conservationists. In this subject, we are talking about the possibility of taking all the coal, yet we all realise that today and in former times, mines have not been worked with the idea of taking all available coal. They have been worked basically to meet a market which very often involves leaving, as in the case of the Greta seam, top coal, the part that is most liable to spontaneous combustion and I don't think that particular problem is confined to N.S.W. We could not really arrive at an answer on how to control this situation. It is perhaps the function of Government and industry to combine and not only conserve the coal but in doing so to eliminate the problems of spontaneous combustion which can aggravate the possibility of recovering the better section of the coal anyway.

We agreed that rank has something to do with the liability to spontaneous combustion but we couldn't quantify it. We believe also that thickness and depth sometimes have something to do with it, but these again are only observations which we could not quantify. We believe there is scope for somebody to do a lot more work in this field with an object of reducing the dangers of spontaneous combustion in future.

We looked at certain methods of control in mines with the idea of not completely eliminating spontaneous combustion but reducing the loss from it, and we agreed that certain types of sensing devices should give us some lead or be capable of giving us some warning and should be further investigated, but from our views the use of temperature recordings in an airway would not present very great prospects.

We noted a reference in one part of Dr. Willett's talk to doors in seals, and although he did not specify it, we were sure he meant, and we want to emphasise as the result of sad experience, that doors which may be required for sealing must be fire-proof doors.

In trying to finalise our thoughts on controlling and reducing losses from spontaneous combustion, we came to two definite conclusions on where and when to seal a heating. They were the closer to the source the better, and the quicker the better.

Finally, Mr. Chairman, we were talking about the prevention of spontaneous combustion, and we decided that this symposium in itself was an aid to the prevention of spontaneous ombustion.

MINE FIRES SEMINAR - REPORT OF DISCUSSION GROUP 5
"THE EFFECT OF FIRE ON VENTILATION"

Mr. Chairman, Dr. Willett, Miss Jacka, Gentlemen,

The discussion started with reference to several fires with which some of the group had had experience. The first of these was the Davidson Shaft fire at the Mount Isa Mine in July 1952, in which a timber shaft caught fire and the airflow was reversed from a very strong downcast to a strong upcast. The second case discussed was the recent Sunshine Mine fire in the Coeur d'Alene area in the United States. Attention was drawn to the fact that at the Sunshine Mine, stoppings at the return airway were not fire-proof. During the fire they were destroyed, allowing the circulation of combustion products through the working areas and resulting in extensive loss of life. In coal mines such stoppings must of course be non-combustible and are often made of brick. The case of a fire in a slightly dipping roadway was also quoted. The mine fan developing 1 kPa to 1.2 kPa was left on throughout the fire but failed to prevent the backing up of methane. In this case management knew what to do but were unable to do it.

Arising from these incidents, discussion evolved around whether there has been any research on fires in controlled circumstances to measure the volume of products, the temperatures that might be developed, the pressures created as a result of the fire and the effects on the air velocity. Comment was sought from Dr. Willett on this.

The use of hurdles or sails was discussed as a means of increasing air flow along the roof. Again comment was sought from Dr. Willett on the use of this practice as a valid way of breaking up the back-up of gases.

The reversal of mine fans was discussed at some length. Reversal is a requirement in the United Kingdom, but in New South Wales it is only suggested as a good practice. Opinion was that a fire must be very close to the downcast before a decision would be made to reverse the fans. There are many unknowns in reversing fans such as the effect on ventilation doors or the effect on the overall ventilation circuit. The group sought comment on the statement, "Is it in fact an outdated requirement that fans be reversible?" The group considered that fan reversal was a last resort measure. Clarification was sought from Dr. Willett in respect of the case he quoted, in which fans were reversed for a fire at the top of a downcast shaft, as to whether the shaft would have upcast anyway as a result of the fire. The most positive approach to fires in shafts is to avoid the use of timber. The provision of fire doors on levels adjacent to downcast shafts was considered desirable, with a proviso that it must be possible to close them quickly.

The next matter discussed by the group concerned the protection required for an upcast fan in the case of a fire occurring relatively close to it. Tar deposition on the fan blades as a result of the fire can cause seizure of the fan thus eliminating its usefulness. Comment is sought on this point.

The effects on workers trying to control a fire when the ventilation flow was reduced was discussed. Reduced air flow might give a less intense fire however the avoidance of flow-back was considered more important than working in hotter conditions. The use of cool jackets was mentioned. These are a relatively recent development by the Chamber of Mines in Johannesburg in South Africa, and consist of waistcoats with small pockets containing water which is frozen. Comment was sought from Dr. Willett on their usefulness for men actually fighting fires.

The next point discussed had already been touched on by several other groups and related to the question of when the decision to seal off should be made. Opinion was that in a major fire, either a whole district, or the whole mine could be sealed off. However no conclusion was reached as to what constituted a major fire. It was pointed out that if sealing had been carried out it was always possible to reopen the mine or the district later. Proper sealing could take several days and the point was made that it was important that the sealing process must be done in safety. In modern coal mine layouts with restricted access, it could be desirable that the wings and foundations of future seals be prebuilt, so that if it is ever necessary to seal off the process it could be done fairly quickly. Sealing would certainly take place if there was evidence of recirculation but in general the feeling was that while there was still a chance of saving lives sealing would not be done.

It was considered desirable to have available the facility to analyse return air samples. However the confidence of action resulting from analysis of air samples will depend on a number of factors such as the amount of dilution taking place in the return airway. Nevertheless it was considered that a readily available facility was desirable at any mine.

The remote control of booster fans in case of fire was discussed. At the Mount Isa Mine remote switches have been provided for several booster fans. They can be turned off remotely but cannot be started remotely. In Australia there are very few booster fans in coal mines and the opinion was that in the event of fire underground power could be turned off from the mine as a whole and any booster fans would go off automatically.

Dr. Willett made some comments about significant differences in United Kingdom and Australian underground coal mines. In the United Kingdom coal mines are by and large deeper; they have single airways of small cross-section and as a result have relatively high pressures over the whole mine. In Australia the practice is to have multiple parallel roadways, shallower workings, headings larger in cross section and as a result relatively low pressures. Comment was sought from Dr. Willett on what effects these differences would have to the actual approach made to mine fire fighting.

The last point discussed has been discussed by other groups but bears repetition It is the importance of pre-planning for fires; firstly the pre-planning of organisation, the call-out procedures and responsibilities; secondly the pre-planning of duties, who does what; thirdly the pre-planning of action, to find the fire and to control it when it's found. There is always difficulty in locating fires at weekends when few men are in the mine. Finally there is the continual need for training and testing to keep pre-planning valid.

MINE FIRES SEMINAR - REPORT OF DISCUSSION GROUP 6

"THE DETECTION OF MINE FIRES"

Mr. Chairman, Dr. Willett, Miss Jacka, Gentlemen,

The group considered the problem of fire detection under two main headings:-

1. Fires from heatings in seams liable to spontaneous combustion.
2. Detection of open fires.

With regard to the first topic, we tended to create more questions than were answered, and rather lengthy discussions developed. Fortunately Dr. Willett was present and was able to make his comments, but because most members here did not have the benefit of hearing him I would like Dr. Willett to comment upon the sensitivity of Draeger tubes as detectors in comparison with the Unor infra-red monitoring system. In addition, are there any other monitoring systems available, similar to the Unor?

One member pointed out, that Chamberlain had reported that where monitoring systems had been installed, no heatings had occurred that had not been detected. Does this record still stand?

The group felt that in mines or seams liable to spontaneous combustion that a CO monitoring system was desirable. However, a few members also though that there was some merit in using Draeger-type tubes to support the evidence from sniffing the return. There was a rather lengthy discussion on this topic and again, as previously, we had the benefit of Dr. Willett's comments. Perhaps, when answering the first question he will also deal with this aspect. The problems of monitoring the monitoring-system against leaks were then raised.

With regard to the second topic, that is detection of open fires, there was a tendency for the group to concentrate on the problems associated with conveyor belt fires. We felt there was a need for educational supplements in the form of booklets and propaganda to highlight the problem. Further, we saw merit in including this topic in the deputies' examinations of competence. There was an emphasis on the need to fully utilize the manpower that was available for the detection of open fires and, of course, this highlighted the fact that fires can occur when the main shift is working. The detection of open fires during the change of shift period, week-ends, holidays and so on requires a slightly different approach. The group would like to hear Dr. Willett's views about the touring and examination of conveyor belts within two hours of the end of a shift. What particular points should be emphasised during this examination?; bearing in mind human failings such as examining the conveyor belt by riding upon it. One member referred to the practice of having 24 hour per day, 7 days per week, 365 days a year belt patrolmen, as is, or was practiced in the United Kingdom. Another member of the group, while discussing this open fire problem, described a 3000 ft. trunk conveyor system fitted with a series of Minerva smoke detectors. If one detector picked up smoke it would activate the red light holding system, then if a successive detector also picked up smoke the sprinkler system was activated. The group would like to know what Dr. Willett thinks of such a system, and if he has any knowledge of a Minerva-type system which had failed to respond when smoke was present. Noting that the pick ups could be activated by a dust cloud, did they fail when there was smoke or fire present? It would appear that they could set off a lot of false alarms.

MINE FIRES SEMINAR

REPLY BY DR. WILLETT TO COMMENTS OF DISCUSSION GROUPS

Dr. Willett. I will start by answering one or two general points which have been posed. The first point is a question of liability of a seam to spontaneous combustion. Some seams are very liable to spontaneous combustion. Some seams are not liable at all except in most abnormal circumstances, and some seams have a liability somewhere between these two extremes. Dr. J. S. Haldane made the comment some 50 years or so ago that if you try hard enough you can make any coal seam in the world fire spontaneously. Many heatings have in fact occurred because the coal has been allowed to be ground up into a fine state and there has been air leakage through it for many years. This has resulted in spontaneous combustion which would not have occurred in some seams unless conditions had been very abnormal indeed.

One comment I heard while listening to the discussions of one team was the importance of encouraging morale and the team seemed to go to the extent of suggesting that this was more important than the actual technical action taken. Though I agree that everything possible should be done to encourage morale, it must be in conjunction with the correct technical method of dealing with the emergency.

The next point which I have heard raised by a number of teams is the importance of not leaving an incipient heating without doing something about it. The whole purpose of adopting means of early detection of spontaneous combustion either by means of the UNOR instrument, by air analysis or by any other method, is to ensure that early warning is given with a view to action being taken to deal with the situation before real danger arises. I cannot stress too strongly the importance of taking effective remedial action immediately spontaneous combustion has been detected.

One or two of the groups referred to the value of boring holes and injecting cement or other incombustible material into the coal pillars, into the road sides or into the goaf. We have found it useful before actually injecting the material to line the road with an incombustible sealant. This has the effect of resisting the outward spread of the fire which injection might otherwise cause.

Another point of general interest is the question of the incubation period for spontaneous combustion to occur. This varies considerably according to the type of coal, its thickness, the type of roof, the method of working, the availability of coal in a broken state and the presence of paths for air leakage. In one of our seams very liable to spontaneous combustion the incubation period in longwall advancing workings is of the order of 10 weeks. Our aim is therefore to ensure that once a coal face has finished advancing the equipment is withdrawn and the district is sealed off within 10 weeks before heating can occur. That is our aim but we do not always succeed. However, there is an incubation period for each set of circumstances and with experience you will find what this is in your own situations. With your methods of working the important thing is to seal off your old caved areas before the expiry of the incubation period.

In sealing off your caved areas before fire has occurred, and I stress that I am speaking only of situations before fire has occurred, suitable stoppings are those which will prevent air leakage and it is not necessary to make them explosion-proof. But I repeat what I said earlier, that such a light type of stopping should not be used to seal off a fire where gas may be a danger. One of the teams seemed to suggest that in sealing off a fire they could erect such light stoppings as temporary seals and see how they behaved. Their suggestion was that if they were blown out then further stoppings could be built. I would ask you to reconsider this point. If you have got a fire where explosive gas may be a danger, explosion-proof stoppings should be built. But as I have said, a light type of stopping built to prevent air leakage only is quite satisfactory for sealing off districts to prevent a fire.

In seams liable to spontaneous combustion preparations for building stoppings at the entrance to the districts are well worthwhile. For example, it is advantageous to make a channel in the roof and sides and floor and to fill this with brickwork, concrete, gypsum etc. so that should it become necessary to seal off the district, this can be done quickly without need for preparatory work. One team raised the question of the vulnerability of men to an explosion for several hours when sealing off a fire. This is so, of course, unless the sites for the stoppings are chosen sufficiently far away from the fire and unless a sufficient air quantity is passed round the fire area until the time for final sealing is reached. During the building of the stoppings it is important to monitor the firedamp content and the carbon monoxide content at the site of the return stopping in order to obtain early warning of any abnormal build-up in explosive gas or of increased intensity of the fire. There have been some cases where such information has led to the abandonment of the initial sites for the stoppings and the erection of stoppings in their place at a safe distance further away from the fire. Before building stoppings to seal off a fire it is a wise precaution to stone dust the intake and return roadways thoroughly for some distance - at least 100 yards - inbye the stoppings.

Reference has been made to conveyor fires and the value of patrolling the conveyors as a means of preventing serious fires from occurring. We have had great benefit in locating conveyor fires in their very early stages since we arranged that all conveyors would be patrolled during a working shift and two hours after the end of a working shift particularly at weekends. The patrol men have been told to take action to prevent fires by noticing collapse idler rollers at an early stage and they have been able to put out small fires either by kicking them out or by the use of one extinguisher. There is no doubt that the employment of patrol men has prevented m. small fires becoming major fire hazards.

The point was made that when a new mine is started miles from anywhere nobody knows whether it is liable to spontaneous combustion, and if so to what degree, and hence whether, in the planning of the working of the seam, to take precautions against the occurrence of spontaneous combustion. This is, of course, a difficult matter. The advice I would give is to take several things into account. Firstly, I would consider the coal rank code. If the coal rank code were 500 or above I would certainly take precautions against spontaneous combustion. Similarly, if the coal was very thick I would also take precautions against spontaneous combustion irrespective of the coal rank code. I think that is the only general advice I could give. I would certainly start the mine on a system based on preventing spontaneous combustion, and would monitor the production of carbon monoxide. I would also determine the normal carbon monoxide oxygen eficiency ratio. It would be better, in my view, to start off in this way and in the light of experience reduce the number of precautions rather than risk losing the mine in its early stages due to a serious outbreak of spontaneous combustion which could not be dealt with in the system of mining decided on.

Though most of our mines are gassy, and as I have mentioned, we have a large number of ignitions due to frictional sparking at power loading machines, the ventilation is generally such that we do not normally ignite substantial bodies of gas. For this reason gas is not a serious problem with us so far as fires are concerned. We have the odd case of what we describe as a hanging flame due to ignition of gas in roof cavities by shotfiring which, when it occurs, necessitates sealing off the district to extinguish the gas fire. There is also the odd case of the ignition of a thin layer of gas near the roof of high roadways due to shotfiring. This, when it occurs, is, of course, a potential danger of explosion. I therefore agree with one Group that although we do not get many gas fires in British mines, when they do occur they are very dangerous indeed.

I agree with Group 1 as to the importance of detection and training to ensure that proper mining practices are understood and applied. I also agree the vital importance of effective maintenance of equipment. We have talked about the use of methanometers and I would like to stress now the importance of ensuring that they are properly maintained and checked periodically at a laboratory in order to ensure that they give accurate readings. We test methanometers at weekly intervals. I appreciate that some of your mines are a long way from a convenient laboratory. Nevertheless, it is important to make the arrangements I have referred to.

One Group mentioned the importance of good housekeeping and the selection of men with special experience to carry out the periodic inspections of all parts of the mine to look for signs of danger.

Reference was also made to the hazard of oil in pipes and of leakages. Research in Britain has shown that pools of mineral oil need to be covered with at least five times their volume of stone dust in order to ensure that they cannot spread fire. It is, of course, important to clean up the mineral oil wherever that is possible.

Questions were asked by one Group as to who makes the decision to seal off a serious fire underground. In our country it is a management decision but the colliery manager has the advantage of advice from a variety of people with special knowledge including specialists employed by the National Coal Board and H.M. Mines Inspectorate, but I must stress that this is not a decision which should be placed on the Inspectorate. It must be a management decision and it is up to every manager and mining engineer taking part in management to make sure that they understand all the principles involved and are ready to make a decision either to seal off or not to seal off in the light of all the facts.

One of the Groups also referred to putting up light seals, seeing how it goes and then putting in another one later. As I have already indicated, I consider this to be a dangerous procedure when there is a fire in a gassy mine but, of course, there is ample room for technical discussion on that matter. It is important that rescue men should be taught during their training and practices how to build stoppings. When they are assisting at an operation at a mine they are, of course, under the control of the mine management but they look, of course, so far as their own safety is concerned, to their Rescue Superintendent under whose technical control they operate and on whom they rely for properly maintained breathing apparatus and other rescue equipment.

One Group stressed the importance of collecting as much preliminary information as possible. This is, of course, most important. It is of great advantage when arriving at a mine where there is a serious fire to know full details of the gas production, the quantities of ventilation, the position of all roadways and stoppings and, of course, gradients. It goes without saying that it is also important to know the position of all old roadways and caved areas.

Group three considers the importance of minimising the water gauge across coal pillars and I entirely agree with them. The smaller the water gauge quite clearly the less the liability to fire both in a coal pillar and in an old goaf.

One suggestion made was that temperatures should be measured as a basis for the detection of spontaneous combustion. My own experience is that temperature is not such a useful guide as carbon monoxide for the detection of heatings.

A further point was raised regarding sealing off which I would like to deal with simply by saying that it is a useful exercise from time to time to look at the plan of the mine and ask oneself "if I had a fire in that part of the mine how would I deal with it ar how would I get materials to seal off the district should that prove necessary?"

Group four started off by deciding that spontaneous combustion could not be prevented. They stressed that it was a question of minimising the occurrence by proper planning and by dividing the mine into small areas which can be opened up and finished with quickly. They rightly stressed the greater technical problems involved in working an old mine than in starting a new one. I agree with all the Group say on this matter with the exception that my experience indicates that in working a new area of coal, spontaneous combustion can in fact be prevented by formulating and implementing plans which take into account all the necessary preventive measures. For example, there is the opportunity to get the shape and sizes of pillars right and to decide on methods of extracting roof coal where appropriate and to install monitoring systems. The same Group felt that the plan of action adopted should be agreed by the management, Government Inspectors and everybody. I agree that it is extremely helpful for the managers to consult with Government Inspectors and everybody who can possibly make a contribution based on knowledge or experience, but as I have indicated in another context already, it is important that the decision on the methods of working should be a management decision. Management must make themselves competent to take such decisions in respect of their own mine.

Reference was made to the injection of limestone and cement into coal pillars as a means of preventing spontaneous combustion. I think this is an excellent thing to do in certain circumstances particularly where there is a high water gauge across the coal pillars concerned.

Group four also raised the question of the use of inert gases in order to gain time either in working or withdrawing equipment before needing to seal off the district. Our experience in Britain has been that pumping either nitrogen or carbon dioxide into districts to extinguish or keep a fire under control has not proved effective. Though I can visualise circumstances in which inert gases could help in this respect, I think that as a general rule it is better to seal off the individual areas as quickly as possible, balance the ventilating pressures on the stoppings and thus produce sufficient inert gases naturally in the sealed area to prevent or extinguish a fire .

The incubation period was raised again by Group four in the sense that the planning should be such that the district would be worked quickly and sealed off before coal had time to fire spontaneously. I support this.

Group four also considered that sensing devices for the detection of fires should be explored but they considered that these devices should not be based on temperature measurements. I agree that more should be done to develop appropriate sensing devices for the detection of heatings. As I mentioned earlier, our experience with fire detectors had not been successful except those based on the production of carbon monoxide.

The same Group took the view that the closer the seal to the fire the better. This is an excellent objective but it is also necessary to have in mind the situation in gassy districts. In many cases it is necessary to work on the assumption that there may be an explosion and it is necessary to give protection to men building the stoppings by carrying out this operation some distance away from the fire.

Group five referred to several actual fires in timber shafts which had involved a reversal of the air. I have seen cases after the fan has been stopped where the air has reversed in the shaft in which the fire has occurred. In some cases this has been due to putting water into the shaft and in other cases it has not. But I do not know of any case where the air in the downcast shaft has reversed when the fan has continued to operate normally.

The question was posed as to whether it was not outmoded nowadays to require that there should be reversal arrangements for the ventilation. My own view is that such arrangements may on rare occasions be the means of saving life provided the reversal arrangements can be put into effect immediately. But, as I have said earlier, a decision to reverse air must be based on a speedy scientific appraisal in each individual case.

Group five also mentioned the fire at Sunshine Mine in America. Investigations indicated that this was due to spontaneous combustion of mine refuse near scrap timber. A number of factors were pinpointed by the investigating team as contributing to the severity of the disaster. Among these were ineffectiveness of the stench warning system; delay in beginning the withdrawal of men; ineffectiveness of the communications system; inadequacy of the escape system; inadequacy of the emergency fire plan; use of a series ventilation system; failure to seal abandoned areas of the mine; failure to monitor the mine atmosphere; failure to construct incombustible ventilation bulkheads; lack of remote controls to major underground fans; failure to maintain self-rescuers in usable condition; failure to train employees in the use of self-rescuers; and failure to conduct mine survival training.

A comment was made about tar deposition on the blades of the fan at the top of the upcast shaft. I certainly agree that this would limit the effectiveness of the fan and that the fan should be stopped at appropriate periods for the purposes of cleaning. Where duplicate fans are provided, as is desirable, maintenance of fans in good condition should not present problems.

I have not had any personal experience of the type of "cool jacket" which has been referred to. But having seen them I feel sure that there will be occasions when they will be extremely helpful to rescue men. I have in mind that they may extend the period during which men in self-contained breathing apparatus can work in an irrespirable hot and humid atmosphere. It is with the same idea in mind that in Britain we have equipped all Rescue Stations with liquid oxygen self-contained breathing apparatus as well as compressed oxygen breathing apparatus. The liquid oxygen apparatus is used for planned operations in hot and humid conditions and the compressed oxygen apparatus is used for quick getaway life saving operations.

Group five also posed the question, when does one seal off a fire, when should sealing be restricted to a small part of a mine, when to a large part or when to the whole of a mine? It is necessary to be guided in making such decisions by the results of monitoring for firedamp and carbon monoxide in the return airway; on a sufficient knowledge of the district to deduce whether firedamp may reach the fire; and, of course, on the layout of the district and possible communicating roads or other channels to other districts. It is best to keep the possibility of sealing constantly in mind while fighting a fire because the earlier a fire is sealed off the less danger and the more possible it is to restrict sealing off to a small area.

The same Group indicated that one should tend towards sealing off a fire because in their view it was always possible to re-open later. If the fire is a friction fire or any other type of fire than spontaneous combustion, effective sealing off and balancing the pressures to produce an inert atmosphere behind the stoppings can ensure that after an appropriate time for cooling off, the district can be re-opened if required. But this is not so if the fire is due to spontaneous combustion. Generally speaking, it is not safe to re-open the specific part of the mine where the spontaneous combustion has occurred, certainly for many years, because of the possibility of the heating starting up again when air is admitted. This does not mean, of course, that it is not possible to send a rescue team through access tubes in the stoppings to build further stoppings inbye which would isolate the length of road or part of the working in which the heating actually occurred and thus enable the rest of the district to be ventilated and worked.

Group five supported the idea of preparing preliminary sites for stoppings and I agree with their suggestions. I also agree with them the importance of having the smallest water gauge possible for effective ventilation. I agree entirely that everyone who may be concerned in an emergency should be properly instructed in their duties so that they know exactly what they have to do when they are called out.

Group six mentioned that Dr. Chamberlain had once said that where monitoring systems for carbon monoxide had been introduced no heatings had occurred which had not been detected by that means. They wondered whether that was the situation. I confirm that that is still the position but I would remind you that so far there are only 30 installations and we have nearly 300 coal mines.

Group six commented that they like the use of Draeger tubes. I also like the Draeger tubes, which are used extensively in Britain, but there is a difference between us as to the circumstances for which these should be used. We use the tubes after a suspected fire or heating has been detected by carbon monoxide monitoring or by normal mine air analysis with the object of locating the origin of the heating. In this respect, the Draeger tube plays a secondary role, even though an important role, rather than a primary role. We also have had great value from the use of Draeger tubes by rescue men. It is on the basis of tests with the Draeger tubes that our rescue men decide where the fresh air base should be and beyond which position they should wear self-contained breathing apparatus. A final point I would like to make on this subject is that the Draeger tube is a most useful tube to have but is not sensitive enough for the initial indication of spontaneous combustion.

The Group also stressed the value of an educational supplement for conveyor belt fires. This would, I am sure, be extremely valuable. I am all in favour of collecting and disseminating as much technical information as possible and keeping the information up to date. Because of the remoteness of some of the mining areas in Australia, I would think that you would get special benefit from the distribution of such information.

The last question I was asked was in regard to the Minerva smoke detector. The value of this detector is that it operates from a primary battery and therefore works when the mains power is switched off. Unfortunately, however, experience in our country has shown that the detector has two main shortcomings for underground use. These are (1) high humidity adversely affects the reliability of the instrument and (2) in dusty environments the detector reacts as if smoke were present and gives a false alarm. So far we have not had warning of fire with such detectors in our mines before the fire has been detected by other means.

MINE FIRES SEMINAR

FINAL SESSION

DR. A. J. LYNCH, CHAIRMAN, SOUTHERN QUEENSLAND BRANCH.

Miss Jacka, Dr. Willett, Gentlemen,

The seminar had its origins in an Inquiry into the Box Flat Disaster and one of the conclusions from this Inquiry was that there should be a better dissemination of technical knowledge and the results of research work. As a result of this Mr. W. Roach, Chief Inspector of Coal Mines in Queensland and Mr. R. Menzies, Chief Inspector of Coal Mines in N.S.W. had a meeting to see how this could be done. They concluded that it would be difficult to have the sort of regular meetings that would be possible where distance was not significant, but a seminar would be a major step toward satisfying this particular conclusion of this Inquiry. As a consequence, Mr. Roach, who is on the Committee of the Southern Queensland Branch of the Institute, suggested when the Branch programme was being planned this year that a meeting of this type should be held, and the Mine Fires Seminar which was held today is the result. We have received a great deal of support in arranging the Seminar. First and foremost I wish to acknowledge support from the National Coal Board in United Kingdom. Not only have they released Dr. Willett for a period of six to seven weeks to visit Australia, conduct the Seminar and give a series of lectures in various areas through the country, they have also borne the brunt of the financial support that has been necessary to make this possible. In addition we have received considerable support from many organisations in Australia. I mentioned this morning the assistance we have received from the Queensland Department of Mines, we have also received support from the Queensland Coal Board, The Queensland Coal Owners Association and the Queensland Chamber of Mines. In N.S.W. the Department of Mines, the Joint Coal Board, ELCOM Collieries and the Australian Iron and Steel Collieries, and in Western Australia, Western Collieries and by Poseidon Limited have all joined in sponsoring the Seminar and related activities. So you see that we have received very enthusiastic support from right across the country. On behalf of the Branch I would like to thank all these organisations.

I would now like to ask Mr. Malcolm Rose, Senior Vice Chairman of the Southern Queensland branch of the Institute, to make the concluding remarks of this seminar.

MR. J. M. ROSE, VICE-CHAIRMAN, SOUTHERN QUEENSLAND BRANCH

At this phase of the seminar draws to a close, it is my task to make some pertinent closing remarks, and to say thank you to Dr. Willett for coming out and taking part in this seminar with us. I have had the very good fortune over the last few days to accompany Dr. Willett on his whistle stop tour over the Bowen Basin and on to Mount Isa, and it has been a pleasure. Dr. Willett survived this tour remarkably well, by the simple expedient of going to bed at the right time; unfortunately as a result he did miss the opportunity of obtaining some very good sapphires. He also arrived in Australia with the sort of thing may people dream about; a very good prescription which required him to have a tot of whisky before he went to bed. We haven't been told if it's on the National Health or not.

As has been indicated previously, the outstanding feature of this tour through the Bowen Basin and Mount Isa, was the intense interest shown by all those who attended the meetings. Not only did senior management attend, there were under-managers, foremen, mine rescue squad members and in Mount Isa the local Fire Chief came along as well. This interest has been outstanding and I am told this was very much the same at the meetings at Ipswich. The grass roots type of participation has been evident again today; all of you have shown it and it has made today's meeting a huge success.

The other outstanding feature of the seminar has been that while this was essentially a seminar born out of a coal mining disaster, it has brought coal and metalliferous mining together and I think that this is significant. Too often the two fields tend to go their own ways, tend to consider that they are different fields with nothing in common. They do have things in common, they do have things that they can learn from each other and I think we can see some of that in the proceedings today. Many of you have heard, no doubt, of the Quebec Safety System. Among the causes of accidents that this system lists is one that says simply "the minds of men". This is the most difficult obstacle that any supervisor has to overcome in his daily supervisory duties. It involves attitudes, it involves motivation, and this seminar has, I think, helped to promote the right sort of attitude to the problem of mine fires; it has helped create a consciousness of good practices.

Now, for a seminar of this sort to be a success, it needs a focal point; it needs someone to set the scene; it needs someone to comment on discussion and above all to provide a sounding board of extensive experience against which we can try out ideas. Dr. Willett has fulfilled this role outstandingly.

You came to us, Sir, with high references; you have more than lived up to them. I would like to thank you for travelling so far and contributing to this seminar. You have come from a large organisation, the National Coal Board, somewhat bigger than any similar organisation in Australia. It is in our industries' interest to foster very close relations with the Coal Board, both for the exchange of information and the exchange of research information. Your visit has been valuable in establishing links such as this. We hope the remainder of your tour will be equally as successful as the first week. It has been stimulating and a pleasure to have you with us and I would like you all to join with me in proposing a vote of thanks to Dr. Willett.

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