EXPLOSION AT APPIN COLLIERY
ON 24th JULY, 1979

REPORT

of

His Honour Judge A.J. Goran Q.C. following an Inquiry by the Court of Coal Mines Regulation established under Section 31 of the Coal Mines Regulation Act, 1912, as amended

His Honour Judge A. J. Goran Q.C.
Court of Coal Mines Regulation

Whereas it appears to me that a formal investigation of the explosion that occurred at Appin Colliery on 24th July, 1979, and of its causes and circumstances is expedient. I Ronald Joseph Mulock, Minister for Mineral Resources and Development in pursuance of the powers conferred on me by Section 31 of the Coal Mines Regulation Act, 1912, hereby direct such investigation to be held and require the Court of Coal Mines Regulation established under that Act to hold the investigation.

Dated at Sydney this twenty fifth day of July 1979

R. J. Mulock

Minister for Mineral Resources
and Development

IN THE COURT OF COAL MINES REGULATION)
HOLDEN AT SYDNEY, WOLLONGONG AND PORT) No. 1 of 1979

KEMBLA

IN THE MATTER of an Inquiry in pursuance of the Coal Mines Regulation Act into an explosion which occurred at Appin Colliery on the 24th July, 1979 and its causes and circumstances.

R E P O R T

TO The Honourable Ronald Joseph Mulock,
Minister for Mineral Resources and Development
in the State of New South
Wales Sir,

Having been directed by your Notice dated at Sydney on the 25th day of July, 1979 made and issued in pursuance of the powers conferred upon you by the provisions of Section 31 of the Coal Mines Regulation Act, 1912, as amended, to hold a formal investigation as the Court of Coal Mines Regulation established under Section 33 of the said Act of the explosion that occurred at Appin Colliery on the 24th July, 1979 and of the causes and circumstances of such explosion, I have completed my investigation and have the honour to report as follows:

GENERAL PRELIMINARY OBSERVATIONS

Most inquiries into fires, explosions and disasters in coal mines which occur in coal mines in the United Kingdom are non-judicial inquiries, the investigation itself being conducted at a senior administrative level. The resultant report takes the form of a description of the colliery and the relevant equipment, followed by a narrative setting out the events. Conclusions are in short form and there is a list of recommendations for future improvements in coal mines generally. A list of casualties (deceased and seriously injured) is relegated to an appendix (see, for example, the report of H.M. Chief Inspector of Mines and Quarries on the explosion at Colborne Colliery, 18th March, 1979,

and the similar report in regard to Houghton Main, Yorkshire, in 1965). I make no criticism of this method of reporting. The report which I now tender, however, is the report of a Court which has investigated an explosion. The conclusions drawn are based upon a mass of evidence tendered before me and tested in the greatest detail by the cross-examination of learned Counsel and laymen of much experience in the mining industry. have had the assistance of two assessors, Mr. W. Smale and Mr. L. Griffiths, both of whom have a deep knowledge of coal mining, its problems, its technicalities and its techniques. I have adopted standards of proof as any Judge must do, accepting some evidence and rejecting other evidence at times which experience in judgment has told me I cannot accept.

This Report is an account of how men came to die while at work. I feel that it is my duty to see that the Government and the people receive a carefully considered answer to the question. The Act which gives the Court jurisdiction also invites me to add "any observations which the Court thinks right to make". In the past I have taken this to be an invitation, inter alia, to make recommendations which the Government may consider adopting for the future safe running of the coal mining industry. On this occasion the parties before me have asked that I make recommendations along lines suggested and argued by them. I include such recommendations as I think it proper for the Court to make. It must always be borne in mind that the duty of this Court is to assist in so regulating the industry that events such as that which occurred at Appin Colliery are not repeated and that men who work in this industry should do so with such safety as can be afforded to them by legislation or by proper practices.

OPENING THE INQUIRY

On the 25th July 1979 after consultation with the Minister I visited the Appin Colliery, arriving at about 1.00 p.m. Under the powers conferred upon me by the Coal Mines Regulation Act I made a brief inspection of surface arrangements for the rescue of men and the recovery of damaged sections of the mine. I held conversations with a number of officials including the Manager, Mr. A. E. Fisher. I held conversations with

Mr. G. Mould, Inspector of Collieries for the district and asked that all documents and materials relevant to the Inquiry be made secure. Mr. Mould also explained and demonstrated to me the recently installed Tube-Bundle gas monitoring system situated at the surface. I made preliminary arrangements with the officer-in-charge of police to protect the mine area from trespassers and to co-operate by photography in recording any matters underground which might be relevant to the Inquiry. I did not see Mr. Metcalfe, Mine Under-Manager, or Mr. Kininmonth, the local Senior Inspector of Collieries, who were both at the time underground, engaged in rescue work.

I suggested to Mr. Fisher, who was in need of sleep and was otherwise obviously under great strain, that he should go home to rest. He was reluctant to do so but I understand that he ultimately took this course.

I visited the mine on the 2nd August, 1979 and in company with Mr. B. Murray of Counsel, Mr, Fisher, Mine Manager, Mr. Kininmonth, Senior Inspector of Collieries, Mr. M. J. Muir, Chief Inspector of Coal Mines, and several other officials, I went underground and inspected in such detail as was possible the area affected by the explosion. At that time ventilation had been at least partly restored to the area, the bodies of the deceased men had all been removed, the locations where they had been found having been clearly marked, but nothing which could possibly be relevant to the explosion had been shifted.

FIRST SITTING OF THE COURT

I held a formal Sitting of the Court in Sydney on the 22nd August, 1979. There I received appearances and appointed my two Assessors. Mr. B. F. Murray of Counsel appeared for the Minister for Mineral Resources I followed the practice of inviting him to act as Counsel assisting the Inquiry. I gave leave to Mr. T. Marling, Q.C. with Mr. R. Stitt, to appear for the Australian Iron & Steel Collieries Limited; to Mr. L. King of Counsel to appear for the Mine Managers Association, Mr. A.E. Fisher, Manager of Appin Mine; to Mr. Maguire, Solicitor, who subsequently instructed Mr. S. Littlemore of Counsel, who appeared for the Electrical Trades Union

and for the widow of the late Mr. A. Brewin, Electrician; to Mr. P. J. Phelan of Counsel who appeared for Mr. K. T. Reed, Electrical Engineer and Mr. F. Metcalfe, Under-Manager; to Mr. A. Brown, Solicitor, who later instructed Mr. J. D. Heydon of Counsel, who appeared for the Australian Collieries Staff Association and for the relatives of the late J. A. Oldcorn, Assistant Under-Manager; to Mr. Whyburn, later replaced by Mr. R. Williams, who appeared for the Amalgamated Metal Workers' & Shipwrights' Union and for the relatives of the late Mr. K. Staats; to Mr. L. Ohlsen, President of the Southern District Miners' Federation, with Mr. Loy, a Mine Check Inspector, who appeared for the Australian Coal & Shale Employees Association; to Mr. L. Leffley, Secretary of the New South Wales Colliery Officials Association with Mr. Penman, President of the Association, who appeared for the Association and for the next-of-kin of the late Mr. R. Rawcliffe. At a later date I gave leave to Mr. C. Bowie of Counsel (subsequently Her Majesty's Counsel) with Mr. Deakin, to appear for the widows of the ten machine men who died during the mine explosion. These latter Counsel withdrew on the 13th November, 1979 with leave to re-appear should the occasion arise.

I wish to acknowledge with gratitude the great assistance which I have received from my two Assessors, Mr. L. Griffiths and Mr. W. T. Smale whose experience and advice was invaluable. Each of these gentlemen adopted a completely impartial attitude throughout the Inquiry and not only assisted me to find my way through the difficulties posed by the evidence, but also, with my concurrence, gave assistance to the parties before me.

It should be noted that Mr. Murray of Counsel was set a most onerous task, Not only was his brief a difficult one but at my behest he opened the evidence in the Inquiry before he was fully prepared.
considered that, although this placed Mr. Murray and those instructing him in an invidious position, to wait for the completion of all investigations by the Department before commencing the actual hearing of the Inquiry would create such delay as would cause uneasiness among members of the public. Nevertheless, Mr. Murray found himself able to cope with this task in a most

skilful manner, and he has not only assisted me to come to what I consider a proper conclusion, but he has done so without complaint and with such expedition as to bring the evidence available before the Court in the shortest reasonable time.

I would be remiss if I did not publicly express my thanks to Mr. A. Neaves, Registrar of the Court. He has made the burden of my Assessors and myself much lighter by his calm organisation of such matters as Courts for hearing, the provision of sound recording and written reporting with their subsequent provision of necessary transcript promptly, and by his care for the carriage and security of the mass of exhibits which have been tendered in evidence. Mr. Neaves is also responsible for the final production of this Report. He has performed his work with readiness and with good humour at a time when he has carried the ordinary burden of a Registrar's duties in an extensive and busy Court like that of the District Court of which he is also Registrar.

THE APPIN COLLIERY

Australian Iron & Steel Ltd. owns a number of collieries on the South Coast and Appin Colliery is one of these. It is situated west of Bulli and commenced production in 1962, some three years after sinking began.

Appin works the Bulli seam, which extends from Macquarie Pass in the south to Newcastle in the north. The width of the seam takes it across the Burragorang Valley. Near the coast it reaches the escarpment where extensive mining has taken place. Its neighbouring mines are Tower and Westcliff.

The colliery produces a very high quality coking coal well comparable with the better Queensland coking coals. This coal is used exclusively for steel production at Port Kembla and the mine is, therefore, a most valuable asset in Australian heavy industry.

The seam at Appin is 2.5 to 3 metres thick. Its average depth below the surface is 500 metres, descending westward at a grade of one in twenty five. There are two main drifts, one for men and materials, the other being the conveyor drift. There are in addition an upcast and a downcast shaft.

The original development plan for the colliery was to drive a main set of headings north and to develop in a rectangular fashion from these. This plan was frustrated by the early discovery of adverse roof conditions in a northerly direction. Accordingly intake air headings were first driven in this direction, planned to be followed later by north-easterly return-air headings.

Soon after commencement of development the Company became interested in the longwall retreat method of extracting coal. This method was devised by the British and German mining engineers and was widely used by Germany during World War II. It was realised that the technology might assist the colliery to overcome the problems of working in the difficult areas. There were, of course, added advantages in the efficient winning of coal. However, because of the gassiness of Appin Colliery, calling for a large number of low-resistance airways for proper ventilation, the management decided to shift development to a north-westerly direction.

Any account of the early history of the colliery highlight the difficulties because of inflammable gas encountered in Appin Mine throughout the whole of its history. Indeed, it is not an exaggeration to say that the story of Appin is a story of methane gas and ventilation problems.

THE LONGWALL SYSTEM AND VENTILATION

Appin Colliery is ventilated mainly by a single fan situated at the upcast shaft. This is a double ended centrifugal fan of the exhaust type, pulling between 440,000 and 480,000 cu.ft. per minute from the mine at about eight inches water gauge. Fresh air enters the mine at the drifts and the downcast shaft. It is pulled through the headings of the mine, being diverted to specific places and areas by stopping, which may be permanent or temporary. Air is diverted, for example, to places where the mainstream of air cannot reach and where methane gas may accumulate. In addition, auxiliary fans are used in such places to exhaust methane gas and coal dust, particularly during actual coalcutting operations.

The general result of this ventilation system at Appin is that on estimate ten or eleven million cu.ft. of methane gas each day are exhausted into the atmosphere via the upcast shaft.

Longwall mining at Appin involves initially the separation of a wall of coal, by panels of parallel headings or roadways, the heading alongside a previously driven longwall being a separating roadway and a fresh panel being driven on the opposite side to form the wall.

The point of origin of each of these panels and therefore of the longwalls themselves were the three development panels of multiple headings driven to the north west. These three panels were known as red, blue and white panels. They were used as access panels for the whole longwall system and apart from serving ventilation purposes, carried men and materials. They were, in effect, approach roads to the longwall panels.

The longwalls and their parallel headings were driven at right angles to this system. At the end of the longwalls panels were driven as return airways from the longwall system, these being the main longwall returns, carrying contaminated air to the upcast shaft.

The panels parallel to the longwalls are approximately 1600 metres in length and the walls vary from 135 metres to 150 metres in width. Thus a longwall ready for extraction comprises a substantial block of coal approximately one mile in length.

The longwall panels are split at intervals by headings known as "cut-throughs", each being numbered from the beginning of the longwall. These are used for access in winning coal from the panel headings themselves and for ventilation purposes.

Coal is won from the longwalls by the 'retreat' method. Appin Coilliery uses continuous mining machines for cutting coal, shuttle cars for carrying the spoil from the miners, feeders for loading the conveyor belts and the belts themselves for carrying the coal to the surface.

In the retreat system for coal extraction the whole block of coal is first surrounded by headings. Along one end of the wall an armoured face conveyor is installed. On it is mounted a shearing machine which hauls itself along the conveyor and shears off the face progressive slices or "webs" of coal varying in depth

from 0.6 metre to 1 metre. Every time a slice is shorn off, the armoured face conveyor is advanced until it is again adjacent to the face. The conveyor uses hydraulic rams attached to hydraulic roof supports. When the conveyor has advanced against the face, these roof supports are free to be lowered individually and pulled across, using the conveyor as an anchor.

The roof is then allowed to fall behind the roof supports and, as in other mining operations,it becomes a goat or caved-in waste area. Traditionally in gassy mines goaf areas are traps for gases emitted in goaves and must be treated with great respect.

In order to avoid goaf gases being carried across the working face itself, Appin Mine uses a kind of "Z" system of ventilation. Intake air goes up both sides of the block. Most of the air going up the maingate roadway - containing the belt conveyor for extracted coal - goes across the face, through the next cut-through, and some of it along the goat edge, through another cut-through where it is joined by other air, all of it passing across the main longwall returns. The upshot of this system is that the goaf gas does not reach the working face where it would create a danger because of electrical machinery and the like which would provide possible sources of ignition.

Thus the mine adopted the longwall system about 1969. There was a partial variation to pillar extraction in Longwall **1**, but in the years following the driving of longwall development panels and the extraction of the longwalls themselves had been repetitive operations.

Up to the time of the explosion six longwalls had been developed and mostly extracted. At that time longwall 8 was being developed. The panels themselves were numbered alphabetically. 'J' had been completed. 'K' was in the process of being driven both to isolate longwall 7 and to provide a maingate for longwall 8, with ancillary ventilation provisions and cut-throughs. The work had progressed to No. **4** cut-through and beyond this line headings were already being driven further into the coal.

It should be noted that coal is won during the development of the headings. The proportion of coal won from longwalls to that won from longwall development roadways is about 3/1.

METHANE GAS

Methane (CH4) is a highly inflammable gas. It is colourless, tasteless and odourless. It is lighter than air, with a relative density of 0.55. Between certain limits of concentration (5+% to 15-%) it forms an explosive mixture with air. The most explosive mixture is about one volume of methane with ten volumes of air. Outside of these concentrations, if there is sufficient oxygen available and a sufficiently high-temperatured ignition source it will burn.

At a concentration of about $5^{1}/_{2}$% of methane the gas burns in an oil flame safety lamp and extinguishes the oil flame owing to its rapid consumption of oxygen. Below this concentration it can be seen as a halo-cap on the flame of a safety lamp at $1^{1}/_{4}$% (some deputies claiming to be able to read 1%), becoming more readily visible with a growing flame as concentration increases before it reaches the extinctive limit.

Methane can issue from floor strata on the coal seam at rib, face or roof level. Owing to its low density it tends to rise to the roof and highest parts of mine workings. If it has issued in sufficient volume without mixing, it "layers" as pure methane, mainly at roof level. A layer, although invisible, can be usefully compared with the ordinary atmospheric cloud, moving physically as a body and requiring substantial turbulence to break it up. Thus layering of methane must always be regarded as dangerous. Not only may layers be moved as such by the general air current through the working places as that current sweeps them out-bye, they may prove difficult to shift in pockets, areas where ventilation may be poor, or behind roof purlins and the like. The interface of layers with the general body of air is always capable of providing an explosive mixture of methane.

Thus ventilation of areas with high methane gas-makes is critical to the safe operation of a mine. As a corollary the official in charge of safety in a panel - deputy or superior officer - must always be alert to check methane gas levels at places where layering may occur. He must also be properly equipped to perform this duty.

Apart from the detection of layering, methane levels in the general body of air must also be checked.

The Coal Mines Regulation Act prescribes certain limiting average percentages of methane in the air under various circumstances in New South Wales coal mines. I have already referred to Appin Colliery's history of methane gas problems. These problems intensified as development of the panels proceeded further with the preparation and mining of new longwalls. It appears to be a generally held theory that the further developments in South Coast Mines move from the escarpment the greater the methane gas problems which they encounter. Another generally accepted conclusion is that such problems are aggravated in some of these mines the deeper they develop into the coal seam.

Certainly these propositions are true of Appin. In the early panels, which were two heading drivages, consisting of an intake and return airway, the return roadway was on the outside, facing the completely virgin coal, the intake heading being kept away from the high make of methane in such coal. Thus the intake air carried a relatively low level of methane to the workingface and gave little trouble in diluting the methane gas made as the coal was won. (Problems of methane gas began to arise in the driving of 'F' panel, with some relief in 'G' panel. However, in 'H' panel there were very severe problems.) The intake air received so much methane contamination as it passed along the heading that when it reached the working face it was at times too high in methane concentration to dilute the methane in the working place below 14%.

It should be noted that mining must effectively cease if this concentration of methane is reached. The Coal Mines Regulation Act, 1912, by Regulation 69 of the Seventh Schedule provides simply:

> "The electric power supply shall be promptly disconnected from any cables or apparatus in any part of the mine where the percentage of inflammable gas in the general body of the air in such part is one and one-quarter per cent or upwards or is such that its presence is capable of being detected on the lowered flame of an oil safety lamp."

There appears to me to be a doubt as to the

ambit of this regulation in that the phrase "part of the mine" is not defined with sufficient particularity. For example, does it include the whole panel, or an entire heading? These may become important considerations in dealing with the extent of the duties imposed upon the deputy on the night of the explosion.

However "part of the mine" certainly includes such part as may be immediately affected by the electric power supply and therefore the coal face which is being cut by a continuous miner operated by electric power. Such machine must have its power supply promptly disconnected if the percentrage of inflammable gas reaches the proscribed concentration.

Appin's difficulties become highlighted by this provision of law. The management properly consulted with the Chief Inspector of Coal Mines and augmented its ventilation of the working place by using two auxiliary fans in parallel and a larger vent tube in order to provide more air for the continuous miner. Mr. Fisher, the Manager, claims to have raised the quantity of available air by this method from about 15,000 cu.ft. per minute to 28,000 cu.ft. or more. The new fan system was commenced about two thirds of the way in 'H' panel and continued in 'J' panel.

It became evident that 'K' panel's problems would not be any less severe. It is described graphically by the Manager. As the development proceeded north-west panel by panel, the distance was approximately 200 metres further on. Each panel was driven for about $1^1/_4$ mile, parallel to the previous panel. During the progression the intake roadway had been giving off methane gas for longer periods after being driven. Methane make in the earlier roadways along the ribs would drop to 15% or 20% of the original make in a matter of weeks. The later roadways were giving off about 40% of the figure they showed after about two weeks, and continued to give these figures for some months. Methane make was increasing steadily and emission in the intake was growing worse. These higher figures could not be accounted for solely by an increased rate of production.

THE DEVELOPMENT OF 'K' PANEL

'K' panel is the panel where the explosion occurred on the 24th July, 1979.

It started, like previous panels, as a two-heading drivage. Longwall 6 was under production and Longwall 5 not quite fully extracted. By May, 1979 'K' panel had proceeded to Number 3 cut-through- At that stage it was estimated that the panel would be finished, that is, completed to its inbye 19th pillar, by about February, 1980. This would have meant that extraction of the newly formed Longwall 7 could begin. Discussions took place at this stage concerning a change in method which would result in the driving of 'K' panel as a 3-heading panel. In early June a decision was made which committed the colliery to this new method of development. This would delay the completion of the panel, and the final development of Longwall 7 if one continuous miner was still used for drivage, by eight months. On the other hand, the centre heading could be used as a single heading for intake air with the headings on either side of it - adjacent to Longwall 7 on one side and virgin seam on the other - becoming return airways. Thus the intake air would, in theory at least, be kept relatively free from methane contamination and ventilation at the face would improve accordingly. Contamination of the returns within limits was expected to create no real problems.

Mr. Fisher insists that the change in development was merely to solve the ventilation problems which were increasing. He points out that on the other hand it brought disadvantages. One was that the third heading was a maingate for a longwall. Ordinarily this would not be driven its entire length before extraction commenced. Under the new system it would bear the weight of the longwall for the entire length of its drivage. Further, the ordinary maingate needed cut-throughs every 200 metres. The new method required the three headings to conform with each other, so that this third heading would require a cut-through at every 100 metres with associated stress and other problems.

However, the most important consideration to the management was better ventilation - not more air, but better quality air for ventilating the face.

Mr. Fisher agrees that to some extent the delay involved would be offset by fewer occasions when production would have to be halted because of methane gas. There can be no valid criticism levelled at the management or the Company for the decision to change [1]1(' panel to a 3-heading system. However, much has been said at the Inquiry concerning the results of the ancillary decisions and procedures of the Colliery.

The first of these was the decision to employ two mining machines working simultaneously in driving the headings. The purpose of this move was to make up for some of the delay occasioned by the new system. Exact co-ordination of the two miners could not be achieved because of difficulties from time to time in deploying machines and supportive machinery and equipment around the headings. Substantially, however, it could be done.

Still, in order to achieve this result, a second auxiliary ventilation fan would have to be introduced so that each fan could be solely responsible for ventilation of the place being worked. Previously, the colliery had had experience of two fans working in parallel. This was quite a different situation. Each fan would need its own separate line of vent-tubing and would require a return airway for its exhaust.

Further, each fan would require its own adequate supply of available air to ventilate properly and to prevent recirculation of inflammable gas and coal dust. The total quantity of air in the headings through June and early July was insufficient for two fans and more would have to be introduced from elsewhere in the mine. With air reaching the working places from a single intake some care would be necessary to make sure that this volume split so as to prevent an imbalance in the quantity available for each fan, leaving one fan starved. The latter task, on a rough basis, should be within the competence of an experienced deputy.

My Inquiry had to undertake an investigation in considerable detail of the methods taken to ensure proper air quantities for these two fans and of the evidence as to whether the total quantity for two fans was available at the time of the explosion. There was a very strong body of opinion that recirculation of air at the fan ventilating the heading where the explosion

occurred was a prime cause of the ignition which triggered the explosion itself.

THE PANEL IMMEDIATELY PRIOR TO THE EXPLOSION

It must be remembered that the shift when the explosion occurred - the evening commencing at 7.00 pm. on 24th July, came two days after the weekend. The 24th was a Tuesday. Reports and work records are available for the days before and for the shifts of the 24th which preceded the night shift. No such records exist for the explosion shift itself, presumably because these are made at shift-end.

There is no coal production at Appin normally at weekends. Auxiliary fans are switched off and working places resort to brattice ventilation, this being considered sufficient by the management to maintain gas-levels at a non-dangerous level by diluting it into the general body of air as it is given off. The theory is that there should be no big makes of gas when the seam is not being worked - at any rate none so large that efficient bratticing cannot cope with it. There is nothing unusual about the use of brattice for ventilation. The part of the heading constituting the working face is divided longitudinally by a curtain of brattice from roof to floor. It thus splits the dead-end heading into an intake and return airway. The intake air flows naturally up one side of the brattice and down the other, the whole air movement being created by the general exhaust-type of ventilation in the mine. The gas flows with the air which is pulled across it towards and down the return airway because of the negative pressure created by the mine's main fan at the mouth of the return heading.

There may be certain difficulties in brattice ventilation. I shall deal with those relevant to my Inquiry at a later stage. However, since brattice generally played an important part in the events surrounding the explosion, it is essential that the technique of using brattice for ventilation be adequately described.

As I have indicated, in normal use brattice forms a curtain when hung. Formerly it was made of a material like hessian which was rendered to prevent air flow through, stiffen it and generally adapt it for the

purposes for which it was used. Present day material is a flexible plastic, woven from fibreglass or material of that nature. The material itself makes a very good seal, but this is limited largely by the imperfections in its final erection. It is usually stapled to props at the edges by use of a brattice-gun, in the possession of the deputy, but made available to the workmen, ordinarily Federation men. There is frequently a middle prop or vertical batten to hold it steady in the centre. It can leak at the ribsides unless an excellent job is done. At roof level it should be stapled to wooden wedges driven behind roof purlins or roof channels. Even so, with an uneven roof it is difficult to make an effective seal. If the drop of brattice does not reach the floor, an apron has to be stapled on, fixing both edges to battens. It should also be weighted at the floor by stapled timber. There may be a difficulty if brattice is to hang over a piece of machinery, like a continuous miner. Thus there are many opportunities for air leaks, particularly in a long brattice hung in a heading.

The difficulties do not end with this description. Frequently brattice must be disturbed for the passage of men and materials. Usually the brattice is split longitudinally for this purpose. The restoration of this split brattice is essential, but difficult to effect, particularly at a time when movement is essential.

The ordinary fixed brattice across a heading should not suffer much from disturbance but is disturbed by workmen from time to time. Nevertheless it can leak fairly substantially. It is estimated that the leak may in some cases reach up to 20% of the air flowing against the brattice, but this figure may be somewhat high. It would be very rare for a brattice in this position not to leak. A brattice across a heading is used as a stopping, ususally temporary in nature, pending replacement by a more permanent stopping made of plaster board or brick, both of which are far more efficient stoppings. A stopping across a heading, whether brattice, plasterboard or brick, is used to cut off a positive air flow in a heading. In this way, the air in a heading may be directed to a desired area, or the heading inbye of the stopping can allow air flowing in

the direction of the stopping to be exhausted into a return airway because of negative pressure in that airway.

By the weekend prior to 24th July 'B' heading, on intake, the heading next to Longwall 7 and on the right hand side, looking inbye, had been driven 73 metres beyond 4 cut-through. 'A' heading, in its left, also on intake, was to commence drivage and by the time of the explosion it extended slightly beyong this cut-through. The third heading, which had been driven back after the decision to change to a 3 heading development, was the Longwall 8 maingate, and it was the return airway at that stage for the panel. It had been driven some 15 metres inbye of 4 cut-through. These advances beyond 4 line or 4 cut-through, were referred to in evidence at the Inquiry as "stubs", and I shall continue to use this term, since it is useful to distinguish the dead-end working place and its immediate vicinity from the previous drivages in the headings. It was intended to continue to drive 'A' heading with a Marietta miner, and after a reversal of ventilation flow in 'B' heading, so that it became a return, to drive the 'B' stub until it reached the line of 5 cut-through, a total drivage of 110 metres, when it would hole into 'A' heading. After an appropriate complementary drivage of Longwall 8 maingate and linking by cut-through, the process would be repeated until the whole panel was developed.

The miner in 'B' stub was a Joy continuous miner, referred to as the 10 CM. The panel had reached the stage where it was to work more or less simultaneously with the Marietta according to the new plan. At the weekend the auxiliary fan ventilating 'B' stub for the 10 CM was moved to a new position in 4 cut-through between 'A' heading and Longwall 8 maingate, with vent tubes into 'A' stub so that Marietta could cut coal in that stub and advance the heading. 'B' stub was put on brattice. It was a very long stub, requiring extensive and careful bratticing. The brattice extended from some 3 metres outbye the face into 4 cut-through. Here it ran diagonally across the cut-through to the actual left corner of the rib formed by the intersection of 'B' heading with 4 cut-through. The ventilation of the stub was then as follows: Air flowed inbye up 'B' heading into the stub. There it turned past the opposite

side of the brattice into the cut-through. Since at this point the brattice in the cut-through blocked the air from reaching 'B' heading, it was pulled down 4 cut-through into Longwall 8 maingate, the return heading for the panel. 'A' stub before the fan was operated was a small stub, requiring little ventilation. It received this from 'A' heading, an intake heading.

The short extent of the maingate stub was bratticed out in similar fashion to 'B' heading stub. It would receive sufficient intake air from 'A' heading (added to air flowing along the cut-through) to ventilate it as a standing place before such air flowed into the return airway formed by Longwall 8 maingate outbye of the cut-through.

It was at this point of development that the colliery decided to effect the changeover in ventilation from two intake headings and one return to one intake and two returns. As I have indicated, 'B' heading was to become the new return and 'A' heading - the centre heading, removed from the block of coal, would then be the sole intake.

In 3 cut-through brattice stoppings had been erected to maintain the old system of ventilation. One such stopping, across this cut-through, between 'B' and 'A' headings, seems to have served the purpose of regulating the flow of the intake air as between these two headings. It was removed by a deputy at an imprecise time some days before 24th July without any serious consequences. Its removal appears to have been required to give access by workmen to the intersection of 'A' heading and 3 cut-through, for purposes which I shall explain. There was also brattice-stopping in this cut-through between "A" heading and Longwall 8 maingate. It served the purpose of separating the intake air in 'A' heading from the maingate heading, a return heading. Without this brattice the air flowing inbye in 'A' heading would have been short-circuited down 3 cut-through.

This brattice was vital to the ventilation change. It became of vital significance during the Inquiry and much time was taken in evidence (examination and cross-examination) and addresses over the subject of this brattice. At one time some days before the explosion, this brattice had become torn and somewhat

ineffective. A deputy, Vasak, who observed this, erected a new brattice about a metre away, between this brattice and the maingate heading. At the shift before the explosion there were thus two brattices in close proximity to each other, the loose, defective brattice being on the 'A' heading side of the other.

THE VENTILATION CHANGE

A planning conference was held on 18th July to cover developments in a number of sections of the mine. It was attended by the Manager, the Under-Manager, Mr. Metcalfe, the Chief Engineer and the Chief Electrical Engineer. Minutes of the conference were taken by the Under-Manager. Planning conferences are usually not attended by any official below these rankings, for example, assistant under-managers or deputies. However, copies of the notes are distributed to higher officials. Deputies may get to see them because they are put on the notice board in the deputies' room and displayed also in the Under-Manager's office, which tends to be a meeting place for deputies beginning their shift. Mr. Fisher says questions may be asked. Both Mr. Fisher and Mr. Metcalfe favour supplementation of these notes with oral communication (including discussion) to those whose duty it may be to put the plans into effect. They appear to rely upon people being told by word of mouth what to do. One would think most of the directions to deputies would come from the assistant under-manager on the shift, apart from the brief typed notes. The effectiveness of communication to deputies became a very serious issue during the Inquiry.

The plans so made on 18th July were apparently somewhat optimistic. They appear to have envisaged that 'B' heading would have been driven its full distance to 5 line when the Marietta started to drive 'A' heading on the 1.00 am. shift on Monday, 23rd July. However this may be, preparations for the ventilation change and the consequent use of two miners simultaneously, each with its own auxiliary fan was projected in some detail.

'A' heading floor was to be brushed by the Marietta while the Joy 10 CM continued to drive 'B' heading. Track was to be laid, belt was to be installed and ratio feeder put in place.

The two auxiliary fans were to be positioned and cables had to be run up the proposed single intake 'A' heading with two gate-end boxes to be the immediate coupling of power supply, one to each of the two headings.

An overcast situated at the intersection of 'A' heading with 3 cut-through had to be completed. The purpose of this was to allow air to pass in two directions. The 'A' heading intake would be contained within the brick walls of the overcast, blocking off 3 cut-through, this intake air passing inbye up 'A' heading. Above the overcast the roof would be hollowed out and sides erected on top of the overcast in line with both ribs of the cut-through. This would allow return air from 'B' heading to flow down the cut-through into Longwall 8 maingate where it would join the return air already flowing down the maingate. This overcast was only completed towards the end of the shift before the explosion, by men working back to get the job done.

The notes then specified that a stopping was to be erected in 'B' heading outbye of 3 cut-through. The effect of this would be to block intake air on 'B' heading. Air drawn by fan or brattice from 'B' stub (and inbye of 3 cut-through generally), would flow back down 'B' heading, turn into 3 cut-through, pass over the overcast and would join other return air in 8 maingate. Thus from the working place to 3 line 'B' heading would become a return airway instead of an intake.

Other matters for working the panel were covered, of course. For example, a second shuttle car was to be introduced and weekend work was a continuing of "panel preparation", referring largely to belt and track installation.

Three matters emerge from a consideration of the planning notes:

(1) Although they contained substantial detail of the work to be done to effect the ventilation change, no mention is made of the removal of the brattice (in fact two, but only one effective) between 'A' heading and Longwall 8 maingate, a removal which was vital to the scheme of allowing return air to flow through 3 cut-through from 'B' heading via the overcast.

(2) No date was specified for the ventilation change, although Mr. Fisher says that it would take place on 24th July, Mr. Metcalfe being in charge of it.

(3) No mention is made of any specific steps being taken to increase the quantity of air in 'K' panel, a step which was necessary to operate two fans.

In fact the ventilation change was started on 24th July, late in the 1 pm. shift. The second fan was in position, outbye of 4 cut-through in 'B' heading. Vent tubes were connected from it, through the brattice to the line of pre-existing vent tubes in the stub. Cables were retrieved and laid in 'A' heading and 4 cut-through. Gate-end boxes were positioned. Cable was laid between the fan in 'B' heading and its gate-end box, but not connected. The overcast was completed, though still "green" and having some holes plugged with brattice. A brattice stopping was erected in 'B' heading, outbye 3 cut-through. The brattices in 3 cut-through between 'A' heading and Longwall 8 maingate were not taken down. Ventilation of 'B' heading was thus short-circuited. The deputy responsible went off duty at the end of the shift. The assistant under-manager had already left, having given the deputy certain orders.

What orders he actually gave become a very serious and important issue in this Inquiry.

THE EXPLOSION

It is established by evidence that the explosion occurred in 'K' panel at about 11.00 pm. or perhaps a few minutes earlier. At about that time Mr. St. Nicolaas, control officer, was in his office at pit bottom, said to be about 3 miles from the explosion area. His duty, inter alia, was to relay messages via the telephone in the control room. He heard a noise "like a vibration" and the lights went off. He could see dust. Some time later he was asked to get an ambulance for Mr. J. Hoffman, who had been burnt. Mr. Hoffman is an electrical engineer, employed at the mine. He was normally due to start work on the evening shift but had been to a lecture at Wollongong Technical College and arrived late at the colliery at

about 8.00 pm. He met the previous shift electrical engineer who passed on to him the work in hand for the shift. Part of this was in 'K' panel, in relation to the location of the extra gate end box and the coupling up of cables (already laid out) for the 415 volt transformer which served the fan and shuttle car. These reticulation cables were not only to be connected to the latter equipment from the gate end box; they had in turn to be connected to the 415 volt transformer and hung on the props. It shoud be noted that the Joy 10CM miner was already coupled to its 1000 volt transformer and had been powered and energised. Hoffman's job was to supervise the shift electrician in this work. Assuming the shift work started at 7.30 pm., he says that these jobs could not have been completed by 9.30 pm.

Meanwhile Hoffman had other work to do on his way to 'K' panel. He checked on materials, waited for transport and arrived at control about 9.30 pm. He had a discussion there about operations with the assistant mechanical engineer and Mr. Oldcorn, the shift assistant under-manager, in which the 'K' panel electrical work was described again. He then left and picked up two junction boxes which he loaded into the diesel mancar and travelled inbye towards 'K' panel, passing the white panel crib room. Before reaching 'K' panel he commenced to mount a junction box which was needed for communication and indication in control as to whether the belt was running. He was not satisfied with its position since it was not safe from road traffic and he proceeded to recess it back in the rib. This work almost certainly saved his life.

As he was adjusting the mounting he heard a noise which at first he thought was "somebody shot-firing along the 'K' panel track road". Although he has no idea of how far away it was, in fact it has been established that he was about a $^{1}/_{2}$ mile from the explosion on white panel track road. The noise was followed by a cloud of dust and a shock wave. This knocked him, apparently, to a crouching position behind the man-car. Almost immediately it was followed by a heat wave. He did not see any flame, but he was facing outbye at the time. The shock wave caused him to lose his hat and he put up his hands, either to retrieve it or hold it on. He received second and third degree burns to the back of both hands and burns of less severity over the

whole area of his head and face.

He stumbled outbye, having broken the lead to his cap lamp and was unable to undo his self-rescuer. He made for the white panel crib room, which was in the next cut-through and found the power had gone off. He says there was a lot of dust in the atmosphere, but there was fresh air in the crib room and he did not need his rescuer, which had given him difficulty on the way.

In the crib room Mr. Viljacik administered elementary first aid until he was able to meet transport to the surface in company with other men being evacuated.

Mr. Viljacik was the deputy in white panel on the evening shift. Shortly before 11.00 pm. he walked to the white panel crib room to prepare the area for his men, who were then completing work in other parts of the panel, particularly 'A' heading. It was exactly 10.50 pm. when he saw Mr. Hoffman passing inbye. Shortly after that he was knocked to the floor from his seat at the table by a sudden blast of air. He felt debris flying over him. Later he saw that the table and floor were covered in grey dust, resembling a mixture of coal and stone dust. He had heard first a hissing noise and with it felt a heat wave. After a few seconds he heard a big thud, resembling a roof fall. The hissing meanwhile continued and when it stopped power went off in the crib room. Visibility was almost absent because of the grey dust. His oil safety lamp, hanging on the table, remained alight.

Mr. Viljacik then heard Hoffman's screams for help and went out to meet him, feeling his way. He gave some relief to Hoffman and rang control, telling them about the explosion without being sure where it had occurred, and asking for transport for Hoffman.

Reassured that he could do no more for Hoffman he left to see what had happened to his men, his main concern. Near 'K' panel heading he was blocked by smoke gushing out of the heading. He returned to the crib room and rang Mr. Metcalfe, advising him to send down a rescue team. He decided to leave in search of his men once again. After walking for some time he heard noise in the crib room, which his men had reached by another road. All were accounted for - 1 electrician and 5 or 6 men. They walked out to meet transport, Hoffman being led because he had no cap lamp. They were

then taken to control and the men left the pit. The work of Mr. Viljacik deserves very high praise.

Mr. Metcalfe rang control and after questions then instructed Viljacik and another deputy, Walker, to go back and check the state of the ventilation system. He found visibility improved in the crib room. At the intersection of 'K' panel there was some marlin burning and he extinguished this. He then checked stoppings in the cut-through and found a number were down. By that time Mr. Metcalfe and the rescue team were coming in.

In Longwall 6 panel a crew was working the evening shift under deputy Mr. G. Wilmott at the time of the explosion. There were 10 men in all, including Mr. Wilmott. Some were working at the face with Mr. Wilmott and the others at the crib room area in the maingate. At about 11.00 pm. they heard a muffled thud and what sounded like a gush of air followed by stone dust. At the same time all power went off and the belts stopped. Telphone lines were dead.

Mr. Wilmott told the men in the crib room to stay there - there were 4 in all. He went towards the face, to get the remainder, but met them on the way out in the maingate. Conditions at the time were dusty, but dust was not thick, and he presumed that there had been a large fall in the maingate outbye. The deputy checked all his men and took them to the crib room, where they could not contact control. He counted his men again and led them to the tailgate, to try to find their way out along that route. Their path took them back up the maingate again, across the face and thence to the tailgate.

At the face the dust was very thick and the air stagnant. Their task was hopeless. Mr. Wilmott counted his men again and decided to attempt an exit through the maingate towards red panel. By the time they reached the crib room they could smell smoke and realised there had been an explosion somewhere. The deputy rounded up his men and instructed them in the use of their self-rescuers, which they all carried. He warned them of the heat and discomfort these were likely to cause and told them that in no circumstances were they to remove them until he told them to. He checked the time they were fitted to the men as 11.25 pm.

and realised they had at least 1 hour to reach fresh air.

Mr. Wilmott then ordered his men to follow him down the maingate, keeping close together. By this time the dust was so thick that there was no visibility. They were guided by the belt structure and the track. Half way along the heading the deputy counted his men again. At the first cut-through of 'H' panel the overcast was down on the outbye side. They had to scramble over another fallen overcast and then reached white panel track road. The air was then clear, without dust or smoke. They had worn their self-rescuers until they reached white panel.

The walk was about $^{1}2$ mile and this took about 40 minutes. During this time Mr. Wilmott noted that the self-rescuers became very hot and he with some others suffered from a sore and burning throat as a result. This, of coure, is the result of a chemical reaction with carbon monoxide within the rescuer. It is highly probable that the men walked through carbon monoxide and the use of self-rescuers helped to save their lives.

Equally important was the help given by Mr. Wilmott. This gentleman originally gained his experience in the United Kingdom, both as a miner and a deputy. His actions showed cool resourcefulness and calm courage in a situation of high danger. His care for his men and his leadership demonstrate the high level of dedication which marks the good deputy. I might add that as witness of intelligence and truth he set an example that some others might well follow.

I have made these remarks because of my belief that Mr. Wilmott's conduct and character should be acknowledged publicly.

THE RESCUE

After being telephoned by Mr. St. Nicolaas, Mr. F.J. Metcalfe, the Under-Manager, came from his home immediately to the pit. He gave instructions for the Mutual Assistance Scheme to be put into operation. This is a plan, adopted by the Southern Mines Rescue Station, where a mine in trouble is given first assistance by its neighbouring mines; incoming calls were stopped and Appin's own rescue men were telephoned. Mr. Metcalfe telephoned Mr. D. Ryan, in charge of the relevant shift

at the rescue station. The Undermanager then ordered the mine's emergency rescue equipment to be assembled and all men coming out of the mine to be recorded, so that they could be accounted for. The mine's rescue men began arriving, and Mr. Fisher, the Manager, had come to the pit. After 5 or 6 men had arrived, Mr. Metcalfe was ready to form a rescue team and go underground with them. At that time the Rescue Station's van arrived. Mr. Metcalfe then handed control over to Mr. Strang, Superintendent of the Rescue Station.

Two teams then went underground together, one made up of 7 Appin men, including Mr. Metcalfe, the other consisting of 5 men from the Rescue Station. At pit bottom they boarded 2 diesel man-cars and travelled down to White Panel. Mr. Viljacik at pit bottom told Mr. Metcalfe that all men had been accounted for, except the men in 'K' panel. Some men were still at pit bottom and went out by the incoming train which had carried the rescue teams. The teams went into White Panel crib room, where they established a fresh air base. The area seemed to have received little damage, although there was much dust.

It was decided that Mr. Metcalfe would captain the team, consisting of Rescue Station personnel, leaving the Appin men as a standby team at the crib room. Mr. Fisher was in charge of surface control and the underground arrangements were communicated to him. The rescue team was to try to effect a rescue in 'K' panel.

They inspected Hoffman's diesel man-car near the 'K' panel entry. There was not much damage in the area. From the 'K' panel turn they could see 2 lights in the 'K' panel heading. They belonged to a Mr. Dowel and a Mr. Burns, who at great danger to themselves had been hosing down some smouldering marlin and generally cooling the area. There were signs of burning on the high tension cable and the Tube Bundle monitoring system. The 2 men were sent back to the fresh air base.

The burning was in 'B' heading of 'K' panel around Blue Panel. Later inspection showed much more damage, including a destroyed overcast, at the intersection of 'A' heading of Red Panel and 'B' heading of 'K' panel.

There was a slight drift of air to 'A' heading of Red Panel. This disappeared inbye and continuous readings of carbon monoxide and methane were taken on a Drager 10B tube - with Drager pump - the usual equipment for reading Caron Monoxide levels. The readings were so high that they went off the scale on the tube - the concentration was in excess of 3,000 parts per million, extremely lethal quantities. The team was using complete mine rescue equipment known as BG 174's and were completely self-sufficient for breathing independently of the surrounding atmosphere.

Visibility was poor and the team found their way by the standard rescue practice of following the track road. The road also led to the 'A' heading crib room, which was one of Mr. Metcalfe's goals. The visibility became limited to about 5 yards, due to smoke and dust and the full face masks they were wearing were also a handicap.

In the crib room, after some time and confusion, the team counted 10 bodies of *'K'* panel men. Following the usual rescue procedures the team marked the location of each body on the roof above. It was obvious that they were beyond assistance. They were very close to each other. Some were in sitting positions at the crib room table and it was obvious that these men had been having crib.

The crib room had been hit with some force, despite the position of the bodies. Inanimate objects had been thrown around, but not for any distance. There were no particular signs of charring or burning. However, some of the bodies were partially covered in soot. All of the men had ingested substantial quantities of carbon monoxide.

It should be noted that it is not part of my function to discover or pronounce upon the cause of death of any of the men in 'K' panel. That is the sole prerogative of His Worship the Coroner, who with courteous understanding and because of comity between our respective jurisdictions, has furnished me with his police medical reports. I would not wish to publish their contents and do not intend to. It is, however, necessary for me to refer to such material in them as is relevant to describe the nature and extent of the explosion at Appin.

Further progress by the team up 'A' heading towards 2 cut-through was impossible beyond the sweeps around the cut-through (a deviation in the track itself); the party could see nothing for smoke and dust. Measurements for both methane and carbon monoxide were very high, unable to be measured on the scale. Ventilation was necessary to clear smoke and methane gas. The party retreated to the fresh air base and rang control at the surface, reporting what they had found. The team was informed that 14 men were missing. A Company mine superintendent was present with Mr. Fisher. Ventilation required discussion before the step was taken, because in that situation it could be dangerous. Finally it was decided to repair 5 damaged stoppings in White Panel belt road to give ventilation to 'K' panel entry.

Meanwhile a team with Mr. G. Sykes of the Rescue Station as captain was sent to draw an accurate plan of the bodies in the crib room. Mr. Sykes' team, after permission had been given, erected brattices to ventilate 'K' panel by reversing the air flow. The operation was started by a team led by Mr. Linnenluke Under-Manager of Bulli Colliery, a stopping being erected in 1 cut-through, directing intake air along Longwall 8 maingate and 'A' heading. Air would then flow mainly through 2 cut-through and come over a fall in Longwall 8 maingate through 3 cut-through. The great danger of this operation, of course, would be if there was any fire still burning in the area. None had been seen.

A considerable wait was required to see the results of this plan. Information came from the surface that the Department of Mineral Resources gas unit was detecting alarmingly high readings of Carbon Monoxide from the pit. Too hurried an entry into the explosion area would endanger lives. Finally, Mr. Metcalfe's team went inbye of No. 1 line. There was little damage in °B' heading between B1 and B2 but the stone dust barriers (erected to halt explosions) had been completely demolished with stone dust over the area. In B2 methane gas readings had come down slightly. Inbye of B2 visibility was again bad, but progress could be made staying close to the floor.

Inbye of B2 there was much debris and walking was difficult because of cables and old belt. Beyond B3 there were vent tubes in ribbons, blown down the

heading. Further on they came across the fan lying blasted a substantial distance from its original site and overturned. Further inbye, some 16 to 20 metres from the fan they discovered the body of Mr. Brewin, the electrician, lying in the middle of 'B' heading roadway. The team took the usual indentification particulars relating to the body and its position.

Medical reports show that apart from other injuries, Mr. Brewin had ingested a substantial quantity of carbon monoxide.

As the party moved to 4 cut-through they encountered the shuttle-car. In the delivery end Mr. Rawcliffe's body was found jammed. Later evidence established that Mr. Rawcliffe was under a heap of miner cable, his damaged safety lamp lying nearby, also in the shuttle car. Medical evidence reveals multiple injuries, but no evidence of carbon monoxide inhalation.

The next area investigated was 4 cut-through, into 'A' heading stub. 'A' heading was comparatively undisturbed, its vent tubes still intact although a little askew. The body of Mr. Staats, machine fitter, was found on the floor at the inbye end of the shuttlecar. Apart from being affected by heat, Mr. Staats had ingested a substantial quantity of carbon monoxide.

Successive rescue teams went below during 25th July until all bodies were removed and reasonably safe temporary ventilation was restored. Among these teams was Mr. J. O'Connell panel deputy for the previous shift, a trained rescue worker who accompanied a team below while noxious levels were still very high. Little of what these men felt when searching for and discovering their former workmates come through in the printed word. Mr. O'Connell was visibly affected in the witness box. Mr. Metcalfe was obviously restraining his emotions.

The body of Mr. Oldcorn, Assistant Undermanager, was discovered by Mr. Kininmonth after he had gone below early in the afternoon of 25th July. His was the last body to be found and was traced by his methanometer, which indicated his presence nearby. The body was on its back lying near the side of 'B' heading between the props and the rib. Mr. Oldcorn's safety lamp was still attached to his belt, as was his self-rescuer. He had suffered various injuries consistent with being involved in an explosion.

Mr. Kinimonth took possession of the methanometer, since it had suffered much damage and was a suspected ignition point for the explosion.

The 10 men who died in the crib room were identified. They were Francis James Garrity, Jungen Lauterbach, Alexander Hardie Lawson, Peter Andrew Peck, Roy Rawlings, John Leslie Stonham, Roy Williams, Garry John Woods, Geoffrey Ernest Johnson and Ian Victor Giffard. It may be of some value to note that most of these men were aged in their thirties or younger.

Nothing but the highest praise can be offered for the rescue operations. The speed of their commencement was matched by the smooth efficiency of the organization under the leadership of Messrs. Metcalfe and Strang. Both the colliery rescue team and the Southern Mines Rescue Station deserve the highest commendation. The work and conduct of the individual men who took part deserve special recognition in this report. The discovery and pinpointing of the location of bodies and objects which could have any subsequent relevance to the investigation greatly assisted my Inquiry. I should add that on my own visit to the colliery, while rescue operations were in progress, I was impressed and moved by the sight of organized relief rescue teams waiting eagerly at pithead for an opportunity to go underground and assist. It shoud be noted that at this time a situation fraught with potential danger continued to exist in the headings under search.

THE NATURE AND EXTENT OF THE EXPLOSION

For much of what now follows I am greatly indebted to Mr. C. Ellis, Senior Scientific Officer of the Safety-in-Mines Section of the Chemical Laboratory of the Department of Mineral Resources. Mr. Ellis, an expert, inter alia, in explosives, flammable liquids and gas analysis, attended the Appin Mine at 2.30 am. on 25th July and stayed until 10.00 am. on the 26th. He has been underground since then on numerous occasions, conducting observations and collecting samples relevant to the explosion for subsequent examination. In all the Chemical Laboratory received and either tested or caused to be tested by the Department's Londonderry Testing Centre 111 items and 45 samples of roadway dust.

The result of the collective work of Mr. Ellis and his colleagues is contained in a comprehensive report which was used as an exhibit at the Inquiry. Later reports were furnished by Mr. Ellis, dealing with other matters and the Inquiry received much material of great value from the Testing Centre at Londonderry. The upshot is that the explosion at Appin has been studied most extensively and in great detail. Not only are the results of considerable value in understanding what happened on the night of 24th July, but they provide material for lessons on future control of fires and explosions in mines in Australia and in other countries of the world where coal is mined in pits. At this stage I propose to deal only with the propositions which flow from the report by Mr. Ellis.

Of the two basic types of explosion, deflagration and detonation, the Appin explosion was probably in the main of the deflagration type, although local detonations may have occurred. The word "deflagration" in its simplest meaning refers to a rapid burning, usually with accompanying noise such as crackling of flame. Since, however, the speed of deflagrations can vary considerably, an ultra-rapid consumption of fuel and oxygen frequently has an explosive force. It is in this sense that I use the word in the Report. There is a flame which travels at a high speed from its original point of ignition. (A simple, household example, very much limited in scope, is the minor explosion of coal methane gas which traps the unwary user of a domestic gas oven. This of course, cannot be compared in intensity of distance of travel with an explosion in a mine).

In theory, a flame travelling at a constant speed, will reveal the following characteristics:

"(a) A shock wave travelling faster than the flame front, and faster than the speed of sound, which raises dust from mine surfaces as it travels, forming a dust cloud;

(b) a flame front consuming some of the fuel and oxygen in the dust cloud;

(c) a region between shock wave and flame front, in which the dust cloud has a constant forward velocity equal to about 85% of the flame speed, and in which the pressure is higher than atmospheric pressure;

(d) a region behind the flame in which velocity is zero, and pressure is lower than in (c) but still above atmospheric pressure."

(Ellis: Report - my emphasis)

These comparative relationships have been well established and tabulated.

It should be noted that in (b) above, coal dust becomes a propagator of the explosion. This is consistent with tests which have been performed at Appin. A coal dust explosion travelling more slowly than 50 m/sec is unlikely to propagate. Putting detonations aside, the maximum velocity is about 1100 m/sec. The sudden variation of pressures between the shock wave and the flame will usually cause stoppings and overcasts in the path of the explosion to fail. Behind the shock wave there is air movement imposing "dynamic" pressure on objects in the path also. Mr. Ellis points to the similarity between the theory of explosions and the eyewitness accounts given by Hoffman and Viljacik at Appin.

In practice there are variations to this theoretical account. The explosion rarely has a constant velocity, accelerating and decelerating. This may account for some apparent inconsistencies affecting certain objects in the explosion's path, particularly in 'B' heading. Further, gases behind the flame cool afterwards producing low pressure areas which may retard the explosion.

My own researches, consisting of descriptions in overseas publications of experiments with methane flame velocity, show that flame speed can be subjected to a number of factors which produce significantly differing speeds. For example, the concentration of methane in the air mixture, or the shape of the area in which the flame travels will bring about differing flame velocities. However, I accept the expert opinion of Mr. Ellis, whose investigation will doubtless receive wide approval from authorities in this difficult field.

The extent of flame or heat travel at Appin has been fairly definitely determined by the gathering and testing of samples of marlin (bolt rope) and of roadway dust, the one being often used as a check upon the other.

Both materials show changes when subjected to heat, the effect upon marlin being visible under a microscope, roadway dust undergoing chemical change by the loss of volatile content from its coal component - such loss being measurable. There is a difficulty in drawing conclusions from dust alone, since much of it may have been carried for considerable distances through the headings by the explosion. It is for this reason that marlin changes will provide good correlation with the inference drawn from dust changes. Marlin itself is fixed to the roof and is not transported.

There were at Appin, of course, other materials affected by flame, such as conveyor belting, power cables, lines for gas monitors, telephone cables, paper, brattice and plastic. A difficulty exists in distinguishing between the effects of flame and of hot gases. Even under a microscope no real distinction can be found between a charred outer layer of rope and one covered by fine dust and soot. No affirmative test has yet been devised for this distinction by the U.S. Bureau of Mines or apparently by any other research body. The Bureau explains the difficulty by pointing out that as it nears its end the flame becomes "thin" and is surrounded by smoke and dust which obscure it.

I therefore refer to the extent of the explosion as the areas affected either by flame or heat without flame. Thus Mr. Hoffman, who saw no flame but was nevertheless burnt was probably the victim of expanding gases at high temperature. For practical purposes the distinction between such gases and actual flame is of little consequence.

After an examination of affected localities it appears most likely that the result of the explosion (flame and/or intense heat) extended as follows:

In 'K' Panel -

The full length of 'B' heading.

The full length of 'A' heading outbye of 4 cut-through.

In Longwall 8 maingate from 4 cut-through outbye to 'D' heading of White Panel, possibly avoiding the fall at 'A' heading of Blue Panel and travelling via White Panel back into Longwall 8 maingate. In cut-throughs 4, 3, 2 and 1 and the cut-through outbye "A' and 'B' headings of Red Panel.

In White Panel -

In 'D' heading from 'B' heading 'K' panel to about halfway to 29 cut-through.

In 30 cut-through between 'D' and 'C' headings.

Possibly into 'C' heading between 30 and 29 cut-throughs.

In Blue Panel -

Possibly weakly into 'C' heading and doubtfully 'B' heading.

In Red Panel -

In "B' heading at least as far as Longwall 6 maingate.

In 'A' heading, strongly to 'B' heading 'J' panel, weakly towards 'H' panel.

In 'J' panel -

In Longwall 7 maingate, 'A' heading and 'B' heading inbye to about 3 cut-through.

In Longwall 7 maingate outbye from red panel weakly towards Blue Panel.

In 'B' heading outbye of Red Panel towards Blue Panel.

There are a number of indications that the explosion was not one of methane gas alone, but was propagated extensively by coal dust as a fuel. A standard test and calculation used by the U.S. Bureau of Mines and applied by Mr. Ellis and his assistants to the Appin situation very soon after the explosion is enough to establish this. In 1954 J. H. Jones and J. C. Trickett published a paper dealing with gases resulting from colliery explosions. They established a formula, now accepted by mine scientists, known as Trickett's Ratio, by which the expert, after an analysis of gases remaining after an explosion, can apply a series of mathematical calculations to determine whether only methane gas or coal dust has been involved in the explosion. A sample of methane gas from the Appin explosion area near the first methane explosion was captured late of 25th July, the day after the explosion. The application of Trickett's Ratio to an analysis of this sample clearly indicates the involvement of exploding coal dust.

Secondly, an analysis of roadway dusts after the explosion corroborates this. The dust consists mainly of a mixture of coal-dust and limestone-dust.

Coal dust contains volatile matter, the proportion of which falls within a fairly close range when it is deposited in roadways during mining operations. Flame during an explosion drives off and consumes this volatile matter, thus propagating itself. The known loss of coal volatiles from the dust remaining in 'K' panel in the area bounded by 'D' heading of White Panel and Longwall 7 maingate - excluding these two headings - is quite conservatively estimated at about 90 KG. A quantity of 90 KG of pure methane would occupy a volume of about 135 m^3 at 20°C. This could reasonably be the quantity of methane which had accumulated in 'K' panel, although even nearly accurate figures as to the latter cannot be obtained. The comparison of these two fuel quantities, however, points to coal dust as a major source of fuel for the general explosion.

Thirdly, the extent of the flame suggests that coal dust was involved. A practical expansion ratio for methane in explosion, accepted by the U.S. Bureau of Mines is 5:1 with a 12% methane-air mixture. The volume of the roadway in that part of the explosion area of "K' panel described above is approximately 30,800 m^3 . If methane were the only fuel involved, at least one fifth of this volume of 12% methane-air mixture, substantially mixed, would be needed - that is 6000 m^3 at least, occupying over 430 metres of roadway. The concept is very unlikely and the great probability is that a major proportion of fuel was coal dust. Finally, the pattern of blast damage suggests the involvement of coal dust. I deal later with the initial damage in 'B' heading stub and 4 cut-through, the clear origin of the explosion on any theory advanced. However, areas remote from these places, such as Longwall 8 maingate outbye 3 cut-through suffered localised violent damage. It is true that there may have been intensive concentrations of methane in localised pockets in these areas. However, while one would not draw a firm conclusion from this evidence alone, it does suggest that coal dust in massive explosive quantities became available to the passing flame and greater turbulence was thus created in those areas. At the same time one should not lose sight of the fact that methane layers could have been discharged, broken up or still in "plug" form, in return airways, despite any strictures against such practices as produce them.

LIMITATION OF THE EXPLOSION

It is almost as important to know why and when the flame of the explosion at Appin was arrested as it is to know why it was generated and why it was propagated. The answer to this question may itself lead to any explanation as to what conditions allowed the flame to continue; equally it can lead to a consideration of what steps can be taken to limit explosions should they occur in future. There has been much research in coal-mining centres abroad bearing directly on these questions. I have had made available to me by Mr. Griffiths, one of my assessors, a wealth of published material from the U.S.A., the United Kingdom, the E.E.C. and Poland. My overall impression (which may be incorrect and therefore unfair) is that while the Department of Mineral Resources has access to such material and has obviously investigated it, there is little Australian publication of research results. If my impression is not incorrect, without making the issue the subject of a specific recommendation, I would observe at this stage that this State's coal-mining industry would benefit greatly by official circulation of specific material upon the subject.

After the initial explosion of methane gas, most of the continuing explosion is believed by Mr. Ellis to have been compared with the most violent explosions (with high speeds for both flame and shockwaves) of a low to moderate variety. An extensive propagation of flame, in the absence of inhibiting factors, could be expected because of conditions favourable to such propagation. These included abundant coal dust with a sufficient volatile content in dry roadways, probable concentrations of methane in return airways, rendering coal dust more explosive, a sufficient supply of oxygen and a strong initiator. The roadways themselves made good flame paths, being long and straight.

Of the possible inhibiting factors only three should be considered relevant:

(1) the release of pressure into multiple roadways

(2) a partial vacuum behind the flame.

Both of these were probably of minor significance compared with:

(3) an amount of inert stonedust in the headings,

which appears to have been largely responsible for

lowering the flame speed and eventually arresting the flame itself.

An analysis of roadway dust samples conducted at the Chemical Laboratory gave results which at first sight are above the maximum combustible volatile matter content of 11.5% after stonedusting prescribed by the Coal Mines Regulation Act (S.54, General Rule 12B (11)(a). The analysis appears to show an even greater breach of the Statute, since what is being examined is coal-dust which has already lost some of its combustible materials through heat.

However, this is a post-explosion analysis of dusts which have suffered the forces of explosion. These forces would have raised the roadway dust - a mixture of stonedust and coal dust, transporting the finer dusts outbye, with coarser dusts settling earlier. The fine stonedust used at Appin would be carried away from many surfaces. The resultant samples of roadway dust used for analysis could not possibly represent pre-explosion roadway surfaces.

In fact particle sizes in Appin roadway dust have been examined and a massive loss of the finest stonedust has been discovered. Obviously this is a field where accurate observations and conclusions are difficult. The matter is further complicated by the probability that a pre-explosion sampling to the normal depth of 6mm would reveal a compliance with the Statute because of adequate stonedusting, whereas the explosion dust cloud would mix fine coal dust with stonedust before re-settlement of both and provide a sample to 6mm. which no longer complied with the Statute.

It is impossible therefore to draw any conclusion that stone-dusting was inadequate in the explosion area. In fact, on the evidence, I should and do draw the contrary conclusion. It became obvious during the course of the hearing that Mr. Metcalfe, the Undermanager, was meticulous, indeed almost zealous, about stone-dusting, and realised the importance of not only dusting freshly driven areas, but of re-dusting areas where coal dust had settled over the original stonedust. His last written message to the late Assistant Undermanager, Mr. Oldcorn, was a specific instruction to stonedust the "advance" in 'K' panel. Finally, the mine work records show continous dusting of the area.

This still leaves open the question of whether, in the light of the Appin experience, the requirements of the Statute are sufficient to provide reasonable safety during explosions or fires in the light of present knowledge available. I am not in a position to make any positive recommendations in regard to the question. I do, however, remind the Mines Inspectorate and the coal-mining industry in general of the practical work done in this area overseas, where similar problems with the comparative failure of stonedust to arrest explosions have been experienced.

Following upon the Luisenthal disaster in the Saar, when 7,200 km. of galleries were affected by coal dust explosions despite stonedust barriers, stone dusted zones and wet zones, the study of the problems arising from the risk of coal dust and firedamp explosions was revived. The results can be found in the llth (1973) and 14th (1976) Reports of the Mines Safety and Health Commission of the Commission of European Communities. Several countries participated in tests and the sharing of information. The result was that the Commission recommended to all member countries that hygroscopic salts be used to bind dust on floors, roof and sides in the form of pastes, powders or flakes or a combination of these. The salts are generally Calcium Chloride (CaC12) or Magnesium Cloride (MgC12) which combined with dampness in the air (present or introduced) to bind and therefore neutralise the dust.

The report recognises certain obvious disadvantages of the method. In very steep workings floors can become very slippery. The method should not be used in the immediate vicinity of trolley wires and the like. The paste can also corrode machinery and methods of preventing this are discussed. Furthermore, stone dust barriers should not be used in conjunction with hygroscopic salts since stone dust is also bound by them and the barrier can become ineffective.

I have already said that I make no recommendations in this regard. I merely draw attention to the fact that alternative methods of inhibiting explosions exist and that stone-dusting, though of considerable help at Appin, still allowed a substantial flamepath to develop. I feel bound to raise the subject, since at my Inquiry I received no evidence as

to possible alternatives or improvements, even although at a very early stage I raised the subject of the sufficiency of current methods quite deliberately, to generate interest and provoke replies.

Appin Colliery used both water-barriers and stonedust barriers in the hope of halting any explosion in the pit. There was one stone dust barrier in the 'K' panel belt-road between 1 and 2 cut-throughs, which was disrupted, throwing its dust into the path of the flame. It failed to halt the explosion. The water barrier was in Longwall 7 maingate. It was also affected by the explosion as intended. What effect it had on the flame was not revealed, probably because the flame passed its location, although I make later reference to this.

I am constrained to say that the system of barriers was not very extensive in the light of the evidence, compared once again with the knowledge available as a result of testing and experience of both stonedust and water barriers in Germany, the United Kingdom, France and Belgium. The rivalry between these two types of barriers appears to be of little importance, although the French experience favours the lower cost of water barriers. The matter in any case may be resolved by new technology, such as is found now in the trigger type water barrier. However, once more I draw attention to a recommendation of the Mines Safety and Health Commission of the Commission of European Communities. I quote from the Report for 1977 at p. 142 (relevant passages only):

> "4.1 To safeguard against explosions of flammable coaldust deposits underground, the precautionary measures mainly designed to avoid ignition and to render such deposits harmless must be supplemented by the provision of explosion barriers to arrest any explosion that may still occur.
>
> 4.3 The layout of the barriers should be based on the knowledge that coal-dust explosions can develop in any roadway containing flammable dust, and in either direction, although gas concentrations and potential ignition sources are more likely to be found at certain points than at others. Water barriers should therefore be installed at regular intervals in such roadways, and particular attention paid to branches and gate roads. Wide-action water barriers rather than concentrated barriers are recommended for use in gate roads."

It was said at the Inquiry that Mr. Fisher had become "involved with water barrier tests before the explosion". Inspector Mould explained that he had given Mr. Fisher information on trigger barriers with the intention of asking Appin to install and test them.

However, the suggested intervals between barriers are to be found in the accounts of experiences in some of the countries involved, and these are no longer new. Mr. Fishers's description of the two barriers at Appin leaves me with the impression that the colliery had little faith in their effectiveness. This is quite contrary to the Report to which I have referred. This colliery, and indeed all collieries where explosions are possible - I emphasize the word "possible" -I do not mean where explosions are likely, should examine their present attitudes with a view to determining whether their precautions against the propagation of an explosion are sufficient. This is a field where discussions with Mines Inspectors and Check Inspectors shoud be salutary.

THE INITIATION OF THE EXPLOSION

The evidence compels me to find that the initial explosion was an ignition of methane. The proposition is thoroughly covered by the report of Mr. Ellis. The contrary was not argued by any party before me; at an early stage my assessors were obviously convinced as to the issue.

Mr. Ellis points out that the alternative to a methane ignition is a "directly-ignited explosion of coal-dust", which is highly improbable. Such an initial explosion, indeed would require two highly improbable situations to occur simultaneously;

(1) A sufficiently highly concentrated coal-dust cloud, somewhat higher than that produced in ordinary mining and reducing visibility to almost nil. It could occur as a result of a major fall and the like, but is improbable and becomes more improbable when one considers the remaining evidence of the results of the explosion in 'B' heading stub, a standing place with no mining operation at the time and no fall of the kind required, yet everything pointing to that place as the area where the explosion began.

(2) A sufficiently strong source of ignition to explode dust.

Laboratory test apparatus could not ignite Appin dust by electric spark or arc, nor can the United States Bureau of Mines ignite samples of Appin coal by such means. Obviously a continuing high-temperature flame or some means of that standard is necessary for the ignition of Appin coal-dust. Such a means would be provided by a prior methane ignition.

The world authority in the field of explosions, Polish W. Cybulski, carried out extensive experiments on the explosion of coal-dust using as a standard source of ignition 50 m^3 of a 9.5% methane air mixture. A fortnight after the explosion - mining having ceased 2 days before that - the 'B' heading face was found to be emitting 1.5 m^3 of methane per minute. It is very likely that at the time of the explosion this figure would have been somewhat higher. Enough unmixed methane would be available in the face area of 'B' heading to mix with air and form, if it did so, 50 m^3 of a 9.5% methane-air mixture in $3^1/_2$ minutes if there was no ventilation at that point. Alternative pictures present themselves under these conditions:

(1) The methane may in fact mix with air and remain in an unventilated general body.

(2) The methane may form a roof layer, still capable of initiating a coal dust explosion.

(3) The methane may do both (1) and (2).

'B' heading rises to the face on an inbye gradient and tends to favour the accumulation of methane in this area.

The U.S. Bureau of Mines has found that "flame from a propagating explosion projects into a dead end only if the atmosphere therein contains an explosive gas-air mixture; flame will not project into a dead end containing coal-dust alone":
(Nagy & Mitchell: Experimental Coal-Dust Suppression.p5).
Thus an explosive mixture of methane and air was almost certainly present in 'B' heading stub at the time of the explosion.

That the ignition occurred in this area is not only most probable from the above, but the fact is confirmed by the pattern of damage in this area. It travelled probably from the face end outbye. The U.S. Bureau of Mines has found (Nagy & Mitchell,supra. p.20) that ignition at the outbye end of places similar to 'B' heading stub produce very weak shock waves, incapable

of stirring up sufficient coal-dust for propagation. On the other hand, the same body of methane gas at the face can produce a very severe explosion. Mr. Ellis adverts to the fact that Cybulski, using roof layers of methane to initiate coal-dust explosions always ignited his layer at the face end of the layer. I note that Coward in England followed a similar practice in 1952 - 2 years before Cybulski.

The damage from the face in 'B' heading stub outbye past 4 cut-through points to a violent explosion from the ignition of a substantial methane gas collection near the inbye-end of the stub. This raises the question of what was the actual point of ignition. Was the ignition outbye of the face area, so that the resultant flame followed a path to the body of methane gas inbye, exploding this methane gas and so causing a flamepath in an outbye direction which ignited and exploded coal-dust? If so, how could the initial flame travelling inbye fail to consume all methane gas on its way, making this unavailable for subsequent explosion? On the other had, an ignition of methane inbye which did not explode, possibly because it was a roof layer unmixed with air in explosive concentration, would presumably travel outbye as well as inbye. If it travelled outbye and there exploded a quantity of gas-air mixture in the explosive range, according to the U.S. Bureau of Mines such an explosion would seem to be incapable of exploding coal-dust outbye of the stub.

However, it must be remembered that the'B' heading stub was not any empty heading. At near-roof level it contained 30" diameter steel vent-tubing hung in sections connected by rubber seals to within some 2 metres of the face. At the outbye end this tubing ran down the main 'B' heading where it was connected to an exhaust auxiliary fan between 4 and 3 cut-throughs. This tubing formed a likely path for flame to travel following an ignition at some point either at its outbye end or along its length further inbye from the fan, provided the tubing itself contained methane gas which would burn. A flame along the length of the tubing, travelling inbye would readily meet any explosive accumulation of methane gas collected near the face, particularly at roof level. This, of course, would answer the questions posed by the results of the investigation conducted by Mr. Ellis.

It became more and more evident,as the Inquiry began to receive evidence eliminating possible sources of ignition which could play no part in an ignition in the vent-tubing, that the most likely flame-path for igniting the main explosion inbye was indeed the venttubing. This is itself, however, raised a question which called for an answer, namely: How was methane gas in the vent-tubing itself ignited?

The question, of course, is important, not only because it might provide yet another source of ignition in a mine-disaster about which care would have to be taken. Its importance extends to confirming and therefore, in that sense, explaining how and where the initial gas explosion had taken place.

The intriguing nature of the question, however, set the parties on a trail of detection on an issue which tended to overshadow a more important issue, namely how and why was a dangerous body of methane - whatever its final size - allowed to collect in a heading, so that it could be ignited by whatever means.

I was constrained from time to time to draw the attention of some of the parties (and witnesses) to the great importance of the question dealing with methane gas. I did so by pointing out that ignition points in coal mines are "two a penny" - at one stage I am quoted as lowering their price to "ten a penny". This, however, is the sad fact in gassy mines, of which Appin is one - hence all the legislation necessary to cover elctrical equipment, the energising of power reticulation cables, flame-proof enclosures and the like. The Act deals in detail with shot-firing and the proof of competency of shot firers, all to control possible points of ignition. They can never, however, be entirely eliminated by legislation, since chance incendive situations which cannot be foreseen are always possible, as men who work in mines well know. A spark from a pick on a sandstone roof will ignite gas as will any frictional spark with sufficient heat and enough gas to burn.

At Bulli Colliery in 1965 when 4 men died after a fire, the ignition was brought about by a piece of wood caught in a shuttle-car braking system being set on fire by the hot brake disc, after being charred over a period of time. In the 1975 disaster at Haughton

Main Colliery the ignition source was the frictional sparking of a fan out of true alignment in its impeller and casing.

I do not suggest for one moment that no attempt should be made to control ingition points. Indeed, legislation should be sufficiently strong in areas of known danger to attempt to prevent any forseeable risk of an incendive nature. At the same time the utmost care must be exercised by mine officials, from managers to deputies and by workmen to prevent sources of ignition which may reasonably be foreseen.

Nevertheless, since what appears unlikely may well be likely and result in death and destruction, there must be an absolute duty on every official in a mine to prevent the possibly dangerous collection of inflammable gas in any place where ventilation is possible and where men may be working or travelling in the vicinity. The duty thus extends over all of the mine workings, irrespective of any statutory provisions dealing with it, for an explosion in one part of a mine may extend through headings to other parts where men may be. Appin is an example. Fortunately, no men other than in 'K' panel died. Mr. Wilmott's crew could have died but for the resourcefulness of Mr. Wilmott. In fact, the explosion at Appin, with more force to it and not an impossible extension, could have reached the goaf areas, with frightening results.

Thus, the suffering of inflammable gas to collect in explosive proportions in 'B' stub is the prime issue for consideration in this Inquiry. On that footing this Report is based, in the hope that such situations can be brought to the attention of those whose duty it is to control mines.

THE COLLECTION OF METHANE GAS IN 'B' HEADING STUB

Methane Gas should not accumulate in any place in a mine if

(1) It is detected or expected

(2) The place is properly ventilated.

These propositions should not have to be stated; they are axiomatic. The Coal Mines Regulation Act provides (S. 54 Rule 1(a):

> "In every mine which is in operation ... an amount of ventilation by air drawn from a pure source, by means of a mechanical contrivance, shall be continuously produced adequate to dilute and render harmless inflammable and noxious gases to such an extent that the working-places ... and workings of the mine and the travelling road to and from those working-places shall be in a fit state for working and passing therein and in particular that the intake air-ways up to 100 metres of the first working-place at the working face which the air enters shall normally be kept free from inflammable gas."

Rule 1(e) provides that

> an intake air-way shall not be deemed to be normally kept free from inflammable gas if the average percentage of inflammable gas ... exceeds one quarter of one per centum."

The rule provides for the method of obtaining an average percentage and for exemption from the provisions of the paragraph by the Minister. The application of this paragraph has been the subject of much discussion among mineowners, Inspectors and Federation men in recent years.

The accumulation of methane gas in a "gassy place" as defined in Schedule VII of the Act is dealt with in the Regulations of that Schedule. I have already referred to Regulation 69. Regulation 27 prevents the switching on of the voltage to any electric machine before a competent person as described makes an examination for inflammable gas with a locked oil flame safety lamp of the place where the machine is to work. If methane gas is found on the lamp (that is 1¼% or more being present) in the place where the machine is to work the machine cannot enter, or if already there, can receive no power. Whilst the machine is switched on the operator must carry out similar methane gas inspections at least every ½hour.

If methane gas is detecEed on the lamp the person finding the methane gas must at once erect a danger fence and report the finding to the deputy of the district or senior official. The deputy must ensure that power is off to the machine and that the trailing cable has been disconnected at the junction box. Thus, if coaling is taking place at the time of the discovery of gas in such concentration it must stop.

The duty of the deputy or his senior then is to determine whether the methane gas is accumulating in any way and shall ensure that it is being cleared away as it is given off or that the quantity of gas issuing is not so great as to render the place unsafe for the operation of the machine. If the place is found to be safe after these tests, voltage for operating the machine may be switched on.

It will be noted that the essence of these safety regulations is the clearing away of methane gas by adequate ventilating of the place where work is carried on. If electrical equipment is to enter or work the preliminary methane gas test must extend to 20 metres from the place where such equipment is to work. However, accumulation of inflammable gases from working places and intake airways generally is a matter of general safety, whether machines are to work or not.

General Rule 4 of Section 54 deals with the inspection and reporting of inflammable gas by competent persons. A pre-shift inspection is provided for, the workmen being kept in stations not closer than 100 metres from the first working place and not within 100 metres of an intake airway confining more than 14% of inflammable gas. The competent person then makes his safety inspection (including methane gas inspection) of inbye working places and travelling roads before allowing the men to enter. This fact and results of this inspection are the subject of a special report. Successive shifts for this purpose are deemed to be one shift.

Similar 2 hourly inspections are to be made during the course of a working shift; and a more extensive inspection must be made at 4-hourly intervals. A special report form contains details as to conditions of methane gas, ventilation, roof, machinery. Sources of danger must be specially noted. These reports are to be left for oncoming shift deputies and officials, and a copy taken above ground to be contersigned by the undermanager or his assistants.

Thus the Act itself highlights the duties of the deputy himself or his superiors in relation to safety and in particular as to inflammable gas. I have, however, publicly expressed the view very stongly that the Act provides but a minimum standard of safety. In

the witness box it appeared that sometimes an official would rely upon the provisions of the Act to defend himself against criticism. I feel that a general attitude prevails among some officials who are bound by the Act that a mere compliance with the letter of its provisions is sufficient to absolve them in any circumstance. It would be impossible, of course, to prosecute any person for breach of the Act who had so complied with it. However, as a Court dealing solely with safety in mines, it is my strong and considered view that such a response by a deputy to the demands made upon him to keep his men safe is not good enough. Mine situations make it imperative that competent deputies and other officials look realistically upon the circumstances which confront them from time to time and meet the problems which arise, guided always by the need to take the greatest care to protect their men from harm. If this dictum needs any support it is to be seen in the actions of Viljacik, Dowel, Burns and Wilmott, whose conduct after the explosion is nowhere provided for in the Act.

I have raised the issue at this time because I wish to make it clear that in a working mine, with men in or near that working place, there can be no support for any action or lack of action which allows a body of inflammable gas to accumulate, whether there is a source of ignition present or apparently neither present nor likely.

Reasons for its accumulation became fairly clear in the evidence before me. However, it must be remembered that the piecing together of sufficient of the events of that shift was a most difficult and intricate task. There were, of course, unfortunately no witnesses from the shift in 'K' panel. Any records that may have existed underground had gone, apart from a few chalk markings made by the deceased deputy Mr. Rawcliffe, during inspections. So much of the area had suffered in the explosion - brattice and the like largely disappeared, vent-tubing destroyed, a safety lamp broken, a methanometer severely damaged, cables seriously damaged and so on. When I went below with the special party to which I have referred, I was confronted with a scene of devastation. There had been falls; the vent-tubes, manufactured from spirals of metal

had in many places become unravelled and the long spirals covered the floor. Walking was quite difficult because of debris and the inspection took some hours.

Yet machinery, tools, personal objects and other matters have been faithfully recorded and examined. They tell a fairly definite story. Coupled with an examination of the explosion path in 'B' heading stub, with steels and roof supports disturbed in an outbye direction, they show the direction of the flamepath which corroborates the views of Mr. Ellis. Beyond that there is:-

(a) the known condition of the panel at change of shift;

(b) a description by witnesses together with an examination of their statutory reports from the shifts preceding the explosion shift;

(c) a testing of the evidence of these witnesses against the background of what is obviously true from a commonsense view of the whole picture.

All of this type of evidence taken together gives a fairly good picture of what must have been occurred during the explosion shift. It then explains to a large extent the accumulation of methane in the 'B' heading stub.

It is important to examine firstly any evidence as to the deputies' experience of conditions in the panel during the shifts preceding the explosion shift. There are deputies' inspection reports to form a basis for what evidence is to be accepted. Care, however, must be taken in evaluating these reports when the deputies themselves give evidence about the subject-matter covered by the reports. The deputies in the witness box may lean consciously or subconsciously to reconstruction of events and conditions. I have now identified certain "areas of concern" among mine officials after the explosion. Pre-explosion methane gas conditions form one such area. After the explosion it behove the people at the mine (and others) to ask what went wrong. It is obvious that discussion of conditions and possible causes of the explosion commenced immediately. It was natural for the officials connected with 'K' panel before the explosion-shift to search for a possible cause of the explosion. Yet I found deputies reluctant to admit

that any such discussions took place even after the announcement of the Inquiry. One matter which would have been of prime importance would have been the existence of CH . In at least one case I found a curious lack of memory as to features which must have been noticed by a vigilant deputy and recalled for a long time afterwards. Such matters give me a certain unease about the evidence.

Nevetheless, the documentary reports themselves cannot be reconstructions, and if indeed they represented the truth at the time of their writing, they were unalterable at the Inquiry. At times they are loose and vague. However, they spell out sufficiently the conditions which obtained. In the days preceding the explosion shift all but one of the deputies detected methane at the working face. On the night shift of the 20th July Wilfred Vasak was the deputy. At that time there were only two effective stubs, Longwall 8 maingate and 'B' heading. The maingate was being driven and gas was diluted with fan and venturi. 'B' heading also had methane - Vasak's 4-hourly inspection reads:

> "CH4 detected at both inbye stubs being diluted into GB (general body) with brattice screen".

He describes the ventilation as "good". Only one fan was working.

The deputy on day shift, Mr. Ashelford, gives an almost identical report. He was followed by Mr. O'Connell on the 4.00 pm. shift, who also discovered inflammable gas at the face and in both stubs. He described the ventilation as "satisfactory". Mr. Rawcliffe, deputy on evening shift, gave a similar report.

I find these reports lacking in definition. They are quite usual in their format and in their descriptions. Deputies tend to follow a pattern in this regard. But nowhere does the deputy state precisely where he found the gas or in what concentration he found it. They were apparently not required to do this. Deputies at Appin were only equipped with lamps - their

"other approved device" under the Act was not another measuring instrument, but a Garforth bulb, which allows methane gas to be collected in a particular location - for example, near a roof or in a corner inaccessible to a lamp, or where the concentration of methane gas is too high to use the lamp. The methane gas is then inserted into the lamp by the bulb through an attachment and then measured on the same lamp. Until after the Inquiry started, deputies at Appin were not equipped with methanometers to measure methane on a calibrated scale. Thus if methane were discoverd, the minimum reading on the lamp must be presumed to be 1.25%. The lamp flame would not take a concentration greater than 5% without spiralling and being extinguished. Within this range, however, the deputy should be able to read his concentration. The reports do not state it. Again, I am suspicious of the continual description of the methane gas as being "diluted into the General Body" or "as given off". Failure to mention dilution would mean that the deputy would have to take special steps to remove the concentration of methane gas. One wonders at times how the deputy comes to recognise this dilution. It is easy to place a lamp near the face and read gas on the flame and then to move the lamp away in one direction and see the cap disappear. What concerns me is whether any further steps are always taken to detect layering and the like. This unease on my part arises from a certain conflict between deputies and between deputies and undermanagers as to methane gas readings in apparently similar places. There is also evidence of other occasions, to which I shall later refer, when chance visits by an Inspector led to methane gas discovery where there should have been considerably lower readings if there had been prior inspection followed by appropriate action. I pause to add that one deputy's report - that of a Mr. Hamilton - is described as the day shift 22nd July report on an inspection of White Panel, 'K' Panel and "PB", yet no inflammable gas at all was found by him, even though it was extremely unlikely that 'K' Panel was ever free from methane gas according to all other deputies.

Vasak's report for the night shift of 23rd July (a non-production shift) reads: "CH_4 detected in in all 3 inbye stubs. All 3 are fenced off". At this

stage, of course, the headings were ventilated on brattice. 'B' heading had reached the extent of drivage which existed at the time of the explosion, as I have already described - a long stub with brattice extending from a short distance outbye the face, the length of the stub, across 4 cut-through to the nearer corner of '13' heading to 'A' heading. In this state its intake was from 'B' heading across 4 cut-through, up the right-hand side of the brattice looking inbye, returning down the opposite side of the brattice back to 4 cut-through, where it returned via Longwall 8 maingate. I repeat, because of its importance here, that any fault in the brattice meant a corresponding loss of ventilation.

Vasak in evidence states why he fenced all stubs off. He says he was not able in the whole of one shift to move that methane gas sufficiently to satisfy himself that this was not a dangerous place, so he left the fences there. He and another deputy refer to the "fencing" material as "cross-sticks", a term used in the Act, but now somewhat archaic since spare timber long enough to reach across a heading is hard to come by. Vasak used 2 props in one heading, a piece of 3ft. by 3ft. with a smaller piece of timber in another and a small piece of timber in the third heading. The custom is for the deputy to chalk his name and the date on the "fence" so constructed.

Such fences, named alternatively as "danger boards", or "cross-sticks" are to be erected by the deputy under Schedule VI of the Act "at the entrance to every place containing firedamp or other noxious gas to a dangerous extent, or which is otherwise unsafe, so as to prevent any person inadvertently entering such place". The Schedule makes it imperative for the deputy to cause any unauthorised person who passes the fence to withdraw instantly (Reg. 40).

On his last shift prior to the explosion, the night shift of 24th July (the explosion-shift being 3 shifts after) Vasak again detected methane gas at the face of 'A' heading, which was being diluted by the fan. The other 2 stubs (he referred to them as "A headings" by error and corrects his mistake) were "fenced off because of methane gas".

Mr. Vasak was of Austrian origin, but although he had some early difficulty with English when he first

entered the witness-box, he soon settled down. Initially he seemed to believe that he was under challenge, and I received the impression that he had not talked about his evidence with deputies or officials. He declared that he prided himself in doing his duty. He had complaints about the brattice supplied for 'B' heading. He stated that the first problem with the Appin brattice that he encountered was that it was always at least 1ft too short and therefore required a small apron to reach the floor. In this he appeared to differ from some other deputies, who saw no such problem. He said there was bad workmanship clearly at roof level where it was stapled to timber. He tightened it as best he could, but asserted that the best way to deal with it would have been to pull it all down and re-erect it in a workmanlike manner. He said it was not one whole sheet of brattice, but several lengths of old brattice pieced together and it sometimes had holes in it. He approved of the ventilation and said that if the brattice had been sufficiently air-tight he could have ventilated the stub.

Vasak differs in regard to the brattice from Mr. Metcalfe, Undermanager, who saw but one fault and ordered it to be rectified, and also from Mr. Ashelford, deputy on the next shift, who did not remember Vasak's fencing off. (Metcalfe saw these, but could only read 1.8% methane near the roof on his methanometer). I felt that there was a tendency by other officials to leave Vasak on a limb, alone, as it were. In fact, Vasak was corroborated as to methane gas by deputy O'Connell's reports, since they show that O'Connell agreed that headings were fenced off because of methane gas. There came fresh problems as to the brattice after Vasak's shift, that aggravated any adverse situation. Mr. Ryan, the assistant undermanager on the shift of 23rd July corroborates him in his report: " - although inflammable gas detected in L.W 8 MG, 'A' & 'B' Hdgs - No Road signs erected, diluting alowly into GB on brattice ventilation". In his report for 24th July he refers to the fact that coaling had to stop to allow inflammable gas to disperse and dilute. I came to the conclusion that Vasak was an intelligent, careful deputy, leaning towards caution more than some deputies did, and substantially telling the truth.

Mr. D. Ashelford was deputy on the shift following Vasak, that is, the day shift. His report states that on 23rd July he found methane in 'B' heading "being ventilated on brattice". Although Vasak in his report had said that he fenced off all three inbye stubs because of methane gas, Ashelford's report makes no mention of this. Vasak had left his timber in place at the end of his shift, and in any case Ashelford should have read his report prior to coming on duty. Conditions may change from shift to shift, of course, but fences with deputies' chalk markings - familiar to all other deputies - do not disappear with a change in ventilation. Ashelford was not asked about conditions on 23rd July in relation to gas. He was, however, questioned as to the state of the headings on 24th July. Vasak had said that the 'B' heading stub and Longwall 8 maingate were fenced off because of methane gas. 'A' heading had methane gas at the face which was being diluted with the aid of the fan. Ashelford said that 'A' heading was clear of methane gas because of the fan and a venturi. Longwall 8 maingate had a "small percentage of gas, between 14 to $1^{1}/_{2}$ I suppose". He found that the brattice in this stub was being disturbed by pressure from the fan in the cut-through and he, together with his assistant undermanager, Mr. McAlpine, decided to repair this and erect a baffle or "spoiler" behind the fan itself to take some pressure off it. He mentioned no fences in this stub. He inspected all the way up 'B' heading and found "a low percentage" of methane gas - between 14 and $1^{1}/_{2}$ in the general body. The ventilation was not as much as he would have liked. He saw no "cross-sticks" in evidence, either there or in Longwall 8 maingate stub. Challenged on this, he added "not as cross-sticks". He seemed to remember some timber lying across the road. When it was pointed out that he had made no mention of this in his report his reply is "I can go up and notice them and check for gas without having to write it down". In fact this 4-hourly report reads "CH4 in all 3 headings, being diluted with Brattice".

I formed an adverse opinion of Mr. Ashelford's evidence on the subject of -methane gas in the panel. It must be remembered that in the real-life situation of a mine, that is outside the Court-room, cross-sticks

and fencing off have a clear meaning to a deputy. Vasak certainly did not warn men that the situation was dangerous merely by leaning pieced of timber across the floor. An alert deputy, such as Ashelford professes to be, would have seen Vasak's chalked writing on his warning fences, and would have recognised them for what they were. In this case, since he had seen them within a short time before the explosion, he could not have failed to recall them.

The result is that while he admits the presence of methane gas he keeps referring to his quantities as a small amount. He does not admit any danger in this methane gas, of course. It is significant that at no time does Ashelford tell the Court that he followed up his general body testing by testing at the face and the roof, although much later he says he made a number of tests at the end of 'B' stub. He describes in re-examination how he generally tests for layering, using a Garforth bulb, but only, apparently when he suspects layering. I am left with an uneasy feeling that methane Ashelford's gas-testing was not all it should His have been. acceptance of $1^1/_4$ to $1^1/_2$% in the general body in 'B' stub, although it was not then a working-the place gives impression that these quantities are with a looked upon certain complacency by some of the Appin. One deputies at wonders what he would have done had he discovered layering. It is true that Ashelford was not very happy with the ventilation generally and had to do the best he could in the circumstances - he called it "fair". But the ventilation of 'B' stub, provided by a long line of brattice, was liable to break down at any time. Indeed, the brattice had to be temporarily disturbed for the miner to be trammed to pick up the new 'B' heading fan which had been dragged by shuttle-car. Men had to move through it. At this stage it was temporary disturbance but not insignificant. Ashelford says the brattice came down to floor level after reaching the miner from the roof and was weighted down at the side of the miner to close any gaps at the floor. This is in conflict with other evidence.

Apart from these matters, however, Ashelford is generally acceptable as a witness. He admitted to a genuine concern at the nature of the change-over of

ventilation, which caused him to ask questions of his superiors and others. He was obviously worried about the length of 'B' stub, considering it had to stand on brattice ventilation alone. He agreed in cross-examination that it would have been better to ventilate it by fan, even though this would mean employing an attendant to inspect the fan during the weekend.

I find it difficult to assess the evidence of Mr. R. McAlpine, assistant under-manager on Ashelford's shift. Mr. McAlpine had been off work for about 8 months due to a spinal injury. He had been back on duty 6 or 7 weeks only before the explision, doing outbye work in 1 cut-through of 'K' panel. During the preceding few days he had been working inbye and thus was in the true sense acting as assistant under-manager. In that position he had statutory duties, one of which was to make an official report after each shift. He made no reports in fact. At the time of the explosion he had been appointed manager of another colliery, but had postponed taking up this position because, according to his claim, he was interested to see how the 3-heading system in 'K' panel worked out, this type of development apparently being novel to him. He described ventilation as "normal" or "reasonable" or "adequate to do the job" on 23rd July. He had accompanied Mr. Metcalfe, Undermanager, when the latter found 1.8% methane with a methanometer at the left hand side of the face about 9 inches off the roof. This was some short time after Vasak had fenced the area off because he considered the methane gas he found to be dangerous. Mr. McAlpine himself found 1.4 to 1.5% "around about that stub area at the face". He said that he thought 2% or "2% plus" would be dangerous. To the very next question he replied, "I don't think I said 'dangerous'". He says he and Mr. Metcalfe agreed that the brattice was not too bad, although he cannot recall what was said. He then qualified this answer by saying that knowing Appin conditions 1.8% methane was not abnormal.

He himself found 1% in the general body the next day but had already forgotten the standard pertaining in the United Kingdom where he had been trained - Mr. McAlpine is Scottish - that 1% or more within 10 yards of the outbye stub must be reported to

the District Inspector because it is considered dangerous. He did remember seeing a cross-stick, piece of lagging or piece of wood lying diagonally across the heading, with chalk writing on it saying "CH4 found inbye". Ashelford was with him at the time and, although he could not recall it, it was probably Mr. Metcalfe who said "We would have to watch that there are no interruptions in the stub" - meaning interruptions to the ventilation.

Mr. McAlpine was prone to making statements and then correcting his memory later. In this respect at least he was an unsatisfactory witness. At one time he claimed to have taken methane gas readings and recited a number of figures purporting to have obtained them at various points in 'B' heading and 4 cut-through. He did this without hesitation and repeated them on request. Yet the memory that enabled him to perform this task months after the event could not retain other matters which he should easily have remembered. He had not written these figures - decimal points of a percentage of methane gas - down anywhere since reading them. His explanation is that he went through the figures in his mind after the explosion a dozen times. In fact when pressed he reeled off some 13 figures which he took over 2 days and which must before the explosion have been impressed on his memory.

He was tested again on the fencing or cross-sticks which Vasak had placed. He denied seeing any fencing in Longwall 8 maingate and then admitted he had seen either a piece of 3ft x 3ft wood or a piece of lagging across 'B' stub. He could recall chalk writing but no initials. He tested for methane gas. He was then reminded that the report of the deputy on the next shift, Mr. O'Connell, had referred to cross-sticks. He then volunteered a piece of novel evidence, somewhat in conflict with his deputy, that Mr. Ashelford had helped him put "another cross-stick across that other stick that was lying across there". At first he gives as his reason for his action that he was concerned that any person going in past the cross-sticks could have been gassed at the face with such a quantity. Soon after, he resiles from the implications of this statement and refers to the brattice - if the ventilation was interrupted by anyone, the methane gas at the face could

have accumulated to a dangerous extent. Therefore, he says, he instructed his deputy "to stay there". Soon after, he explains that he meant that he instructed Mr. Ashelford to stay with that operation - what operation is not quite clear - until this job was finished.

He repeats that he saw no cross-sticks proper or improper. He did see a piece of lagging lying on the ground or something like that and he may have stepped over it.

It is impossible for me to rely upon this sort of evidence. However, it does indicate that there was a methane gas problem in 'B' heading of which Mr. McAlpine was well aware and that the delicate balance of effective ventilation to keep methane gas levels down could easily be upset in the ordinary course of work.

On the shift prior to the explosion itself Mr. J. P. O'Connell was the panel deputy. His report for 23rd July - the day before - shows that he had found inflammable gas at the 'A' heading face and was diluting it with the fan. In the other two stubs methane gas was also found. In fact his report shows that this methane gas was found outbye from 'B' stub until the brattice was closed up. He notes that cross-sticks were erected in both places and methane gas was diluting slowly. In evidence he states that he did not erect the cross-sticks, but found them already in place. He recognised that they were warning fences but could not remember what form they took. In the maingate stub the , barrier would have been close to the entry. In 'B' stub they were half way up.

O'Connell agreed that there had been discussion about the events between the deputies, but he had never spoken to Vasak. He had spoken to Mr. *F.* Schuster, his assistant deputy for 24th July.

In his report for the 1.00 pm. shift of 24th July, that is the shift immediately prior to the explosion-shift, O'Connell reports that there .was inflammable gas at the 'A' heading face - still the only working-face. He had to position a venturi and extend the vent tubes to maintain an adequate dilution. In both standing stub ends he again noted the methane gas and again stated that it was outbye of 'B' stub. He repaired and repinned the brattice at B4 intersection. Once more he notes the presence of cross-sticks.

In evidence he stated that these were the same cross-sticks as on the previous day. He passed them and had walked down the intake side of the brattice, checking for methane gas as he went. When he found a concentration of about 2% methane about 10 or 11 bars (11 or 12 metres) off the face, he expected to find a higher concentration further inbye. The reading was taken at about head height. He retreated to the crib room to obtain his tools to fix the brattice when he was diverted by the miner driver who was having trouble with the methane monitor cutting off power from his machine.

He came back finally with his brattice tools and first went to Longwall 8 maingate stub where he stapled loose brattice to a heavy prop and put an elbow on the exhaust of the fan to divert pressure from the brattice which was behind it. Then he proceeded to 'B' heading. He checked for methane gas on the bratticed corner and found none. He went inbye and repaired the brattice on top of the miner, pinning it to the roof channels and stubs. He discovered other faults at roof level. He then stood on a drum to repair a split in the brattice at the cut-through. He returned to the 'B' stub again and found no methane gas where he had found it before. At the end of the brattice, some 2 or 3 metres from the face he found 2 to $2^{1}/_{2}$% methane. He then came outbye. The time was about 4.00 pm. He paid attention to the miner, which was in difficulty.

O'Connell said he had seen worse brattice rectified. He described it as "good quality, clean brattice, new brattice", although it may have been in several lengths. I pause to note that the length of brattice required would be 85 metres, too much for 1 roll. He said there were no holes in it and no excessive leaks at floor level. It should be noted that O'Connell gave a different account of the quality of the brattice and the state of the brattice from that given by Ashelford and Vasak. He said also that the brattice was in one piece from roof to floor - that is, there was no apron stapled to it. Again, the brattice did not run down the side of the miner, but came round the back and across the top.

This conflict is significant and I do not think it can be explained solely by lack of memory.

All men had their attention drawn to the brattice as the sole means of ventilation of a gassy heading and all must have remembered the state of the brattice over the days when they saw it. Ashelford appears to concede that the whole situation had its difficulties. Vasak makes a point of this. O'Connell seems to be saying that he had left everything in near-perfect order and that his work had been disturbed by somebody else. He goes so far as to say that the brattice was so tight that as he walked along it a breeze was created that caused the brattice to billow.

That was the last time on the shift that O'Connell saw the brattice. He had, according to his standards, left it in good condition, although he had last measured $2^{1}/_{2}\%$ of methane near the face and had left warning signs inbye. He went to the 'A' heading area, outbye for his tea and wrote reports. When he was leaving he met Mr. Rawcliffe coming in past the crib room at 1 cut-through and spoke to him. His first account of the conversation was that "the face was O.K. but that he was having trouble with the drivage. He was not sure at what stage Felix (i.e. Schuster) was up to." Rawcliffe's reply was to tell him not to worry, he had an experienced miner driver on the Marietta and that he would fix everything up.

It is to be noted that O'Connell was quite aware that Schuster and his men were working in the panel and in particular would work in 'B' heading. Although he denies that he knew the ventilation changeover was to take place on his shift, he knew on his own admission that preparations for the changeover were taking place on his shift. This involved a number of things that concerned the 'B' stub brattice. One was the movement of men through the brattice itself and there is no doubt that a vertical slit existed in the brattice at **4** intersection for this very purpose- there is abundant evidence from workmen who were under Schuster's control as to this. The vent-tubes had to be put through the brattice and a hole made for a 30-inch diameter tube to go through and be re-tightened. The workmen who performed this job appeared ignorant of the fact that this process would lift the brattice off the floor. One of Schuster's last actions according to him, was to repair a leak in the brattice which worried him, apparently above all else.

It should also be pointed out that the undermanager, Mr. Metcalfe, agreed that brattice left lying on top of the miner instead of down to the floor by the side of it, was unsatisfactory. It could be the source, of course, of a substantial interruption to ventilation. Mr. Metcalfe was certain that when he visited the stub on the day before, the brattice was not left in this state. It is clear that it had been shifted since then, possibly to move the miner.

For the sake of completeness I would point out that Mr. Rawcliffe's last report, for the evening shift of the 23rd July, refers to gas at the face and at the face also in both stubs. It is strictly not evidence in the real sense, but it casts no doubt on the general picture.

The upshot of all this evidence is that the management had driven a very long stub in a gassy mine, which was shill an intake airway, although a narrower intake alongside the longitudinal brattice. It had been left standing on brattice ventilation. The make of methane gas at the end of the stub was at least 22 m^3 per minute, demanding careful ventilation.

It is possible that brattice ventilation, in the best of repair and thoroughly tightened to prevent more than the minimum leakage, could adequately maintain sufficient ventilation to keep methane gas levels down, However, this mine was conducted by men of great experience. They must have known that the brattice could be materially disturbed and that ventilation could break down, at least temporarily, allowing methane gas to collect which would be most difficult to remove. The undermanager himself saw some danger, for he issued an instruction that the brattice would have to be watched carefully.

The undermanager, Mr. Metcalfe, recognises the true position. He begins by saying:

> ... the CH4 position was capable of being dealt with if the brattice had been maintained in a satisfactory condition at all times."

Later:

> "Q. Would you say that the situation as reflected in those reports was a healthy one for the panel?
> A. Yes, I would say so. Under our circumstances, yes.

Q. I do not quite understand that, Mr. Metclafe; it might be good under your circumstances But your circumstances may be such that it still in general leaves a condition that is unsatisfactory as far as mining is concerned; as far as the safety of the men is concerned.

A. ... I don't know if I meant that implication, Your Honour.

Q. ... What you are saying to me is this: we have this troublesome problem; we still want to produce; we are taking steps. In the meantime, what our deputies tell us is just really consistent with what has been happening all along. Is that not really what you are saying?

A. Yes, Your Honour. What the deputies are saying is fairly consistent with these types of workings....

Q. In other words, they are only telling you something you know about? Yes, definitely.

Q. The brattice has to function and the ventilation has to function well, if you are to get a satisfactory situation there?

A. Yes.

Q. Otherwise, you will get a layering of gas..?

A. Yes, you will get an accumulation for sure.

Q. And in fact, it will build up in a very short time?

A. Yes."

And some questions later:

"Q. ...But it seems to me that something happened down below over which people did not see the significance and did not take the great care that should have been taken..?

A. Yes, there has been a condition there that somebody has failed to recognise, I agree."

Unfortunately, the task was left to deputies and assistant undermanagers who had other things to do in the panel. One at least did not give the maintaining of the brattice the importance it necessitated. The last deputy, O'Connell, left it for some 2 hours or more unattended. Yet all deputies claim to be competent to handle situations similar to that which existed in 'B' heading. Never at any time did I hear of a

suggestion made to a superior officer by a deputy that the situation was other than ordinary, let alone dangerous.

THE VENTILATION CHANGE-OVER

The 3 basic steps in changing the system of ventilation were firstly, the building of an overcast at the intersection of 'A' heading and 3 cut-through; secondly, the erection of a stopping in 'B' heading outbye 3 cut-through followed finally by the removal of existing stoppings in 3 cut-through between 'A' heading and Longwall 8 maingate. The overcast was necessary to allow intake air to continue to flow up 'A' heading, while at the same time return air flowed down 3 cut-through, over the roof of the overcast, into the maingate, which was already the return airway for the 3-heading panel. In order to direct this flow from 'B' heading, a stopping had to be erected in that heading outbye the cut-through to divert air into the 3 cut-through. The removal of existing stoppings in 3 cut-through between 'A' heading and the maingate opened the path for this air to flow - indeed, the negative pressure in Longwall 8 maingate induced air to flow down the cut-through. The last 2 steps building a stopping and removing another stopping should have followed each other in quick succession so that the ventilation would work. Failure to do so, as already explained, would mean that air flowing into **4** cut-through from the only intake remaining, that is 'A' heading, could not be induced to flow past the 'B' stub brattice to ventilate the stub, carrying contaminated air down what was now the new return, namely 'B' heading. The importance of these 3 steps cannot be overstressed.

There were, of course, ancillary steps besides these. Cables and equipment had to be moved from 'B' heading, now a return airway, and laid and hung or sited in the sole intake, 'A' heading. Firefighting equipment had to be re-located. These were time-consuming tasks. Because of the extra 'B' heading fan a gate-end box had to be placed to provide power for the fan and the 'B' heading shuttle-car and this had to be energised by cable from the 415V transformer. The Joy miner was already powered up from the 1000 volt transformer - the vent-tubes had to be connected from the existing vent

line inbye 'B' heading stub to extra tubes linking them to the new fan. Because they were 30 inch diameter and larger than the fan intake a connection had to be made with brattice to make sure the joint did not leak.

The overcast was built over a period of days and there appeared to be no certainty as to its time of completion. It was overseen by an experienced man, Mr. J. Christ, who had helpers. On that afternoon shift they were working overtime to complete the job, having worked the whole of the the previous shift. It was a builder's task, the basic materials being brick, steel rods and cement.

At its completion, instead of a permanent stopping being erected of plaster board according to the final plan, 2 men stapled a temporary brattice stopping to props in 'B' heading outbye 3 cut-through.
A brattice stopping has the defect not only of allowing a certain leakage of air - on this occasion it would flow inbye up 'B' heading against any return air moving outbye in the direction of the cut-through - but it is subject to disturbance by workmen. I have already described the disturbance of the brattice in 'B' heading stub. A different but not unusual type of disturbance is that which the brattice in 3 cut-through between 'A' heading and the maingate suffered. Originally these had been one brattice. Now there were two. The first was described by one deputy as "tatty". It hung loosely and appeared to be detached from the props at its sides. Vasak, the deputy, thought it better to renew this brattice than to repair it. He erected another brattice, tighter than the first, about 1 metre from it on the maingate side. There were thus two brattices and they remained in place and were seen by the undermanager, Mr. Metcalfe, on the 23rd July. The latter fact becomes important in assessing the evidence of certain witnesses. Mr. Walsh speaks as if there was only one brattice up on the 24th and suggests it had been loosened to allow cool air to flow down 3 cut-through from 'B' heading because the men working on the overcast were getting hot.

The fact that 'B' heading was on intake meant that the brattice in the cut-through was most important. If it was loose or leaking at all substantially, ventilation to the stub would be cut down accordingly

by the short-circuiting of intake air. If it were loose before the body of the overcast was built, 'A' heading intake air would be short-circuited also. One obtains the impression from this evidence that interference with brattice was by no means unusual and that repairs were effected some time after the ventilation system had noticeably deteriorated.

In fact, the brattice in 'B' heading was stapled to the wrong side of the props - the inbye side, where it could offer far less resistance to the air-flow from outbye. For some reason, Schuster, the deputy whose job was to supervise the changeover, did not notice the error until the brattice had been erected. In time if left in that state it would come away. As it stood, it provided a temptation for anyone walking up 'B' heading and not expecting to be barred, to shift the brattice partly and make a passage for himself. Mr. Prinz, one of the men who erected the brattice, gives the simplest reason for erecting it on the wrong side. They just happened to erect it from inbye. Not unnaturally, he says the brattice was tight and "rather good". He walked out and saw Schuster in the crib room. He had already passed Rawcliffe and his men going towards the face to assume control.

Mr. F. Schuster was a second deputy on the same shift as O'Connell. His duties consisted mainly of preparation work for the ventilation changeover. He had been told on the surface to go to 'K' panel to do some extra work as a deputy and at pit bottom Mr. V. Walsh, assistant undermanager for the shift, gave him instructions. Schuster appeared quite hazy as to where he received his instructions. At the 'K' panel crib room he claimed to have received instructions regarding the vent line from the panel deputy, O'Connell. Walsh told him that the ventilation changeover would take place as soon as the overcast was finished. In the meantime he was to retrieve cables from 'B' heading and re-route them down 'A' heading. He was also told to complete the vent-line and as soon as the overcast was finished to erect a brattice stopping outbye 3 cut-through. He was then to ring Walsh back. Walsh wanted to know how far he had reached with his work in respect of the power, the vent and his stopping.

Previously Schuster had made a statement to Inspector Mould in which he had stated that Walsh had given him his instructions by telephone in the crib room. He finally compromised by saying he had received the same instructions both at pit bottom and by telephone in the crib room. He was asked whether he knew that the general plan was to convert the panel from a two intake system to a single intake system. His reply is interesting:

> "That is a bit tricky one, this one. I knew of course from the general outlay, I knew what was going on, from the general outlay of the panel."

I pause to revert to what I have already described as "areas of concern" among the officials in the colliery, and in particular I have referred to pre-explosion methane gas conditions which after the explosion must have worried the officials to the extent thay they presented the Inquiry with a picture of care taken that methane would not collect in 'B' stub - a picture which cannot really be supported by the evidence. There was also a strong effort to convince me that although no specific instructions could be proved by documentation, every concerned deputy knew as if it was a routine matter (a) what the nature and purpose of the ventilation changeover was and (b) precisely what steps had to be taken to bring it about. It is clear on his evidence that Schuster at least did not really understand (a). He was in fact led through the steps of the changeover, having said " - I would have a fair idea of what was expected of me and what was going on". The answers were almost fed to him. In the course of this exercise he was asked whether he knew that the erection of a brattice stopping outbye of 3 cut-through in 'B' heading would be "blocking off the intake air in 'B' heading". His answer is:

> "Blocking off is a bit of harsh statement. Reduce that airflow in any case, because a brattice stopping will never be that tight that you block it completely off".

Strictly, of course, he is right - brattices do leak in varying degrees. But the whole purpose of this stopping was substantially to block off intake air and he did not really know this elementary step. In fact he adds later "Well, as far as I could make it out I thought that is only a very temporary measure, that brattice stopping, it had to be. Just to start the changeover

off".

I regard this part of Schuster's evidence, coming as it does early in his examination before anyone could reach him and explain to him what was actually being done in the changeover, as vitally important. It explains much of his later failure to grasp the significance of making the move which was complementary to erecting his 'B' heading stopping - the removal of the 3 cut-through brattice. He had little idea of what dangers would be created by this failure. He needed to be told to take down this brattice - I strongly doubt that he was ever instructed to do this - and it was precisely the attempt to make me believe that he was given the instruction that became an area of concern as I have described it.

Schuster's position on the panel was somewhat anomalous. He had no real inspection tasks - he was very much like a foreman in charge of a gang of men. While waiting for the overcast to be completed he set about his allotted duties in regard to cables and the like. He appears to have been held up for some time by a loco being derailed, but the preliminary work at least had been finished by the time he went to crib at about 6.00 pm. Soon after, at the latest by 6.15 pm., the overcast was completed and he could give orders for the stopping in '13[1] heading to be erected. He says he received the latter instruction from Walsh shortly before he went to crib. He left 2 men to erect that brattice and inspected the brattice in **4** cut-through to satisfy himself as to the passage of the vent tubes through it. At some time after 7.00 pm. the men on the stopping were completing their task.

Schuster noticed that the brattice was pinned to the wrong side of the props. But the men had done a sound job, he says, it was only a temporary measure and he decided to leave it as it was. He then made an inspection of the area at 3 cut-through. He claims to have noticed that the air, instead of now flowing from 'B' heading through the cut-through, was moving in the reverse direction to 'B' heading. He also noticed a flow inbye of the new brattice in 'B' heading up the heading, and concluded that there was, as usual some leakage through this brattice. He returned to 3 cut-through and reviewed possibilities to account for the flow.

He then claims to have stood on an empty mortar drum and looked at the brattice on the other side of the overcast. He could only see one brattice but could see the whole of it from about 5 metres away. It was complete, with no holes and was very tight. He says he had seen two brattices there previously and assumed there were still two, but could only see one. He came to the conclusion that the leakage came from the overcast because it had yet to be plastered. He did a methane gas check. Then he made a decision about whether to take down the brattice in 'B' heading, newly erected. He tried an air check with drifting stone dust and again noted the inbye flow in 'B' heading. Mr. Schuster came to the conclusion that 'B' heading would be adequately ventilated for a short time "which it was supposed to be anyway". He said he decided "it will do for starters".

He spent the rest of the shift at the brattice partition in 4 cut-through to 'B' stub. He noticed there was a gap underneath the vent line where the brattice came over it. There was alo a gap on the rib side on the outbye side of 4 cut-through. He attempted to close the gap on the rib side but could not immediately close that under the vent-tube. Also in his "subconscious" he thought there would have to be a methane gas check taken before that could be closed completely. He did not say why. It took quite a time for Counsel to get him to the point where the leakage of air which he noticed would have gone through the gap in the brattice at 4 cut-through and so short-circulated the stub.

He did not report this situation to O'Connell, the panel deputy. He did not have to make reports. He says that he rang Walsh at his request at shift-end about 7.30 p.m. and also told Rawcliffe, the oncoming deputy of the state of affairs as to ventilation, including the fact that he had not removed the 3 cut-through brattices. At one stage he said that he advised Rawcliffe to "shut up shop".

O'Connell, the man who should have known what was happening in regard to ventilation of the panel for which he was responsible, was not told about it. Walsh had told him that the ventilation changeover might take place towards the end of his shift or during the

next shift. Walsh himself seems to have been uncertain as to the time. The operation depended upon the completion of the overcast. Schuster makes the assertion that O'Connell knew what he was doing, but can ascribe to O'Connell no real knowledge of the vital steps of changing over the ventilation. There appears to have been no contact between the deputies after about 5.00 pm. O'Connell himself did not inspect 'B' heading after he had left it for 'A' heading.

Schuster agreed that he knew the removal of the brattice between Longwall 8 maingate and 'A' heading was a vital matter. He said he knew it before he went off shift. He agreed that it was urgent. He had seen it about 15 minutes before his shift ended. He had been instructed to remove it but he did not do so. He gives varying reasons for not removing it. It would have taken him a mere 3 or 4 minutes to pull it down. At one stage he says:

> "Subconsciously, of course I did not want to miss the transport. If you are not there, bad luck for you mate."

On another occasion he says that the proper thing would be to lift the brattice up halfway to see what would happen. Then he says he left it to the oncoming deputy and he had told the undermanager.

It is impossible to accept all of Schuster's evidence and the real difficulty is to decide how much of it can be accepted. When he first gave evidence he mentioned no instruction to remove the brattice in 3 cut-through, but after an adjournment he spoke about it. He says that Walsh had told him to ring and tell him how far he had got. He rang Walsh at shift-end, about 7.30 pm. from the crib room. He does not give the impression that Walsh was unduly concerned about the matter. He wanted the information passed on to the oncoming deputy.

It is difficult to avoid the conclusion that at the time Schuster knew very little about the method of changing over the ventilation. He was told to do specific things which brought it about. He was not told the theory behind it, simple though it was. Finally he agrees:

"Q. Have you not really provided me with the correct answer to-day, that is nobody really told you what was happening and you had to assume things for yourself? Nobody really told you how it was to happen?

A. Nobody told me.

Q. You had to work out things for yourself; is that really right?

A. Yes."

This cloud of doubt over his evidence also casts its shadow over the statement that he told Rawcliffe of the situation. It is impossible to believe that he had been told the offending brattice had to be removed, noticed a reverse air flow, saw the brattice and failed to remove it, let alone ask o'Connell's advice. This is a schoolroom lie. It goes further - one has to doubt whether he even looked for the brattice before assuming that any reversing flow of air came from the overcast. If he in fact looked, he could not help but see the torn brattice on his side of the overcast. Walsh did not see it either, and one wonders about him. Yet Mr. Metcalfe had seen it and it is clear from his evidence that anybody who looked could not have missed it.

As his evidence progressed over a matter of days it was quite apparent that his knowledge of what in fact had happened in the panel was being corrected and augmented by some person who knew better. His first attempts at explaining the ventilation system were confused, even though every time he was asked about pulling down the 3 cut-through brattice he would use phrases that demonstrated his apparent mastery of the situation, such as "it was a foregone conclusion" or "that goes without saying". He agrees that after the explosion people were checking with him to see whether he had pulled the brattice down. It would be unnatural if they did not, he agrees. He says he "could not come to an answer one way or the other on the brattice screen whether he was told to take it down or not". Indeed, so great was his doubt that he deliberately asked Walsh on one occasion whether Walsh had told him to remove the screen. When Walsh told him he had, he turned and abruptly walked away. He claims that he must trust his under-manager. At the same time he allows to slip out

a claim that he is "taking the rap". His final statement is that he cannot recall whether Walsh gave him these instructions or not.

Walsh gave evidence that he had given Schuster these instructions through Mr. Christ, in charge of building the overcast. He had earlier said to Schuster that they might have to "start the changeover in the ventilation on that shift". He explains that at the time he did not know whether the changeover would be started or not. The second occasion he instructed Schuster and Mr. J. Christ, who was supervising the building of the overcast. He said in the hearing of Schuster that Christ should tell Schuster when the overcast was finished so that Schuster could erect the screen on 'B' heading outbye 3-line and pull the brattice down between the overcast and Longwall 8 maingate. He then turned to Schuster and said: "Do you fully understand what is going on?" Schuster replied "Yes," etc.

It will be seen that Walsh is prone to gilding the lily. The conversation is not borne out by Schuster. The account is only partly corroborated by Christ, who repeats Walsh's words but only saying this is what Walsh was going to tell Schuster to do, Schuster not being present. He appears not even to have told Schuster that he finished the overcast. Walsh did not find in Christ a very useful ally.

At about 6.45 pm or 6.50 pm to 7.00 pm. Mr. Oldcorn, according to Mr. Walsh, rang him from the surface as was his custom before going below at 7.00 pm. to receive instructions as to the state of the pit. Walsh told him that they had started the changeover of ventilation; that he expected the screen to be up on **'B'** heading; that he did not know how much further they would get, and that they had reclaimed cables from 'B' heading and re-run them into 'A' heading but as yet they were unconnected. Oldcorn asked him about stone-dust. Then Walsh remembered something he had forgotten to mention to the Court. He told Oldcorn "to get the deputy to check on the screen between the overcast and Longwall 8 maingate and if this was not pulled down he was to get Mr. **B.** Rawcliffe to pull it down straight away".

He was unable to give satisfactory reasons why he would tell Oldcorn about the screen when Oldcorn

already knew the screen had to come down. Later, he added a significant detail which he had not mentioned before. As he was speaking to Oldcorn he heard him speak to Mr. B. Rawcliffe who, he presumed, was standing close to him and "he told Bob about it and he said he would have to check it as well".

I have already mentioned Mr. Walsh's tendency to "gild the lily". This is but another example of it. The effect, of course, is to make certain that I should believe, that both Oldcorn and Rawcliffe knew the 3 cut-through brattices were up and had to be removed. Yet at that stage Walsh would have no knowledge - presuming he had in fact given Schuster the instruction - or indeed if every deputy, including Schuster knew these brattices had still to come down - that there was the slightest need for Rawcliffe to make the check. He could (if indeed he had needed to) ask Schuster on changeover.

Again, Mr. Fisher's account of seeing both Oldcorn and Rawcliffe on surface before the shift, does not bear out the story. Mr. Fisher's evidence is that he saw and talked to Rawcliffe, quite apart from Oldcorn, and some short time later saw Oldcorn emerge alone and call some remark to Rawcliffe about stonedusting - quite consistent with the written instructions he had just received from Mr. Metcalfe. Mr. Fisher gives no account about Oldcorn mentioning brattices or changeover to Rawcliffe. I have come to the conclusion that Mr. Walsh's account will not bear examination.

I have already described the failure to remove the brattice as an "area of concern" for the mine officials after the explosion when the Inquiry was announced. The first effort was to lay blame on Schuster for not carrying out an instruction to remove it. Schuster appears, having at first omitted to mention this instruction, to have gone part of the way with any such suggestion which may have been made to him. His method is to describe his supposed sighting of the brattice and to have given what seems to him to be an adequate reason for not removing it. He then attempts to escape by his telephone call to Walsh, which ensures not only that Walsh knows about it but that Oldcorn and Rawcliffe will know also. Nowhere does he say he told Walsh about the reverse airflow. Indeed, he gives no reason to Walsh for failing to remove the brattice.

He said it never crossed his mind to tell Walsh that he thought he should "close the shop and go from there", that is, turn off the power and try to establish normal ventilation. Yet his evidence is that he told this to Rawcliffe.

So we have it established by Schuster that Rawcliffe knew about the brattice and no fault for anything that occurred thereafter could be ascribed to Walsh or himself. The real question is whether he is telling the truth when he says he informed Rawcliffe. The first answer to this question is the great difficulty in believing that he knew that he himself should have removed the brattice. I have already dealt with the unreality of the conflicting reasons which he gives the Court. I draw attention to his failure to grasp the urgency of the situation. On his own statement he is busy repairing very defective brattice at B4 intersection when what he is doing is useless because the heading is not really being ventilated in any case. He estimates that he saw the offending 3 cut-through brattice a 15 minutes before shift's end. He spoke to or passed Rawcliffe at the crib room at 7.30 pm. It would be close to 30 minutesr (at one stage Schuster says 40 minutes) from the time the new **'B'** heading brattice started to interfere seriously with ventilation in the course of erection to the time Rawcliffe, assuming he knew about it, could remove the 3 cut-through brattice. During that lengthy period the accumulation of gas in **'B'** heading stub would be massive and highly dangerous. Layering would be certain and gas outbye at least in 4 cut-through or down 'B' heading outbye the cut-through would not be improbable.

If Rawcliffe were not informed, of course, the situation would be calling for disaster unless he promptly realised what happened and took appropriate action. The hopelessness of Schuster's position is demonstrated by his admission that he cannot remember whether Walsh told him to pull down the brattice or not. At one stage in cross-examination he says almost desperately:

> "You want me to agree that he didn't tell me. I have been in considerable trouble about that question. I am really sorry I mentioned it in the first place. Everything would have been okay if

I would have said he did tell me and take the rap anyway".

The attempt to convince the Court that Rawcliffe and Oldcorn were fully informed as to the failure of Schuster to remove the 3 cut-through brattice is at its strongest in the evidence of Walsh.

There are strange features about this account. In the first place, if Walsh had given the instructions to Schuster which he claims he gave, he had no reason to expect that the 3 cut-through brattice would not be pulled down. The conversation itself contains purported information that the changeover had started but that Walsh did not know how much further they would get. After all, with the overcast completed, as I have already emphasized, there only remained two steps (apart from possible regulation of air flow after the changeover) - the erection of the 'B' heading brattice, taking possibly up to one hour and the pulling down of the cut-through brattice, taking less than 5 minutes. Indeed, both Walsh and Schuster appear to believe that the later stages of the changeover could be spread over both shifts. If Walsh really had any appreciation of the risk he was incurring through Schuster running out of time, it is a wonder that he did not leave the two last operations to be performed by the oncoming shift. In examination Walsh concedes that the 'B' heading stub would remain almost unventilated while the cut-through brattice remained in place. He says that if Rawcliffe went straight to the screen after arriving at the crib room by 7.30 pm. it would take him 15 minutes or a little longer before he could pull it down. When Oldcorn rang him he did not know whether the screen would have remained in position for a period of up to 40 minutes.

It must be remembered that according to both Schuster and Walsh, Schuster did not ring Walsh until shift-end - about 7.30 pm. The question then arose as to how he was able to tell Oldcorn that he expected the screen to be up in 'B' heading. He had been in the district until after 6.00 pm and he did not know whether the overcast would be completed on that particular shift. But he had at least to know that the overcast was completed to be able to tell Oldcorn about the erection of the'B' heading screen. At this stage Walsh began to flounder. It would be kind to him to say that

his memory was at fault. However, he started to invent explanations. His first attempt was to remember a message from Schuster that they were going to start erecting the screen. This, or course, would be yet another conversation. It would be in conflict with Schuster. It would give little excuse for Schuster to be required to ring at 7.30 pm. and inform Walsh as to his rate of progress. Worse, however, it would have provided Walsh with the ideal opportunity to remind Schuster to remove the 3 cut-through brattice and would have removed the need for him to warn Oldcorn about it and therefore Rawcliffe.

Walsh then said he thought the message was from Schuster, but that he was not too sure. Perhaps the bricklayers told him that they had finished the overcast and that the brattice was going up in 'B' heading. He then said that he had passed the information to Oldcorn that they had started to erect the 'B' heading screen, so he must have received the information but he could not remember how.

Some 40 minutes later, that is, at about 7.30 pm., about 10 of 15 minutes after Oldcorn had come into control, Schuster rang Walsh at control from the crib room. He was then, of course, about to take transport to the surface. According to both Walsh and Schuster, the latter told him the 'B' heading brattice was erected but Schuster had not pulled down the 3 cut-through brattice. Walsh says he got a bit of a surprise. He did not ask Schuster why he had failed, because Schuster's transport was waiting. Pressed about his surprise, he added that he was disappointed. He said he told Schuster that he had better make sure he told this to Rawcliffe. Schuster replied that he had already told him.

Thus Walsh has an account which, if accepted, absolves him from blame. In the first place, the fault is not his because he has told the deputy what to do and the deputy has failed. He is corroborated by no credible evidence. Schuster appeared ready to take the blame, but backed off. Then Walsh has told Oldcorn and through him, Rawcliffe, what to expect before it happens. He then has Schuster ringing him to say he has failed to pull down the brattice - at one stage Walsh says because of lack of time. Oldcorn has already told

Rawcliffe. Now is the time for Schuster to tell him. Schuster has already told him. Rawcliffe is therefore fully briefed, and the brattice must have been pulled down ultimately, even though it has prevented ventilation of 'B' stub for some 40 minutes, according to Walsh.

Schuster, however, says he told Walsh on the telephone that his reason for not removing the brattice was because of the reverse airflow, which might be coming from the overcast. Again, he did not in fact tell Rawcliffe "to remove the brattice". He told him of the reverse flow of air which had caused him not to remove it and advised Rawcliffe to close down the shop and start again.

In this maze of contradictions there is one piece of documentary evidence which assists in arriving at something like the truth. It is the written statutory report for the shift made by Walsh to be found in the Undermanager's Report Book. After writing about the methane monitor on the Marietta miner in 'A' stub (a subject to be dealt with later), he states that the overcast in 3 line is completed. The ventilation changeover has been started but not completed. Among other panels, ventilation is adequate.

This report was written after Walsh came to the surface - at about 8.00 pm. Therefore he should have known both about the 'B' heading brattice and the 3 cut-through brattice. He mentions neither; this is not remarkable in itself, because the information may be included in the statement about the ventilation. What is strange is his description that the ventilation is adequate, when his belief ought to be that 'B' stub is unventilated. He admits in the witness box that the report is untrue - indeed, he concedes that it is a lie. Further consideration has led me to think that the document really is not a lie - that it may well describe what Walsh believed to be true. I have little confidence after watching and hearing Walsh in the witness box that he really understood fully the significance of the new ventilation system in 'K' panel. After all, 'B' stub was not yet on fan ventilation, and the whole of his evidence gives the impression that he did not appreciate the methane gas difficulties of 'B' stub. He failed to calculate the time lapse between shifts and it was not a matter of great importance to him that a

ventilation changeover begun on one shift, once it reached the stage of erecting stoppings, could not be safely extended to the new shift. That he appreciated no difficulties is obvious from the fact that he did not tell O'Connell that the change was taking place on that shift, even though he was the panel deputy. He told Schuster at the commencement of the shift that the change might not take place until the next shift. Indeed, at times there appears to be a feeling that Schuster is only doing preparatory work for the next shift. In a sense he was - the vents and cables were not going to be used on that shift. O'Connell did not even notice the change in ventilation, even though he must have had 'B' heading intake air coming up 'A' heading in addition to the pre-existing flow of air inbye along 'A' heading.

'B' heading stub, at the conservative rate of $1^1/_2$ cu. ft. of methane-make per minute, must have accumulated some 60 cu. ft. of pure methane over a period of 40 minutes. Some of this would layer, some mix with air to form a probably explosive mixture. This was by about 7.40 pm to 7.45 pm., assuming that Rawcliffe then knew of the trouble and removed the 3 cut-through brattice. One cannot do more than speculate about this, if one discards the evidence of Walsh and Schuster (as I do) and comes to the conclusion that Rawcliffe was not told about this brattice. I certainly cannot find on the evidence of these two men that he was so told. I have very convincing evidence that he was not told and am satisfied as to the fact that he assumed duty not knowing the true position.

A situation of great difficulty then met him. Even if he discovered the brattice and removed it, his task was very difficult indeed. He could rely properly only on brattice to de-gas the stub. This brattice was in such a poor state and the stub was so long, that the brattice had failed on previous shifts to remove all the methane gas. Now there was the new accumulation. It is of some significance that the explosion took place almost $3^1/_2$ hours after Rawcliffe took over. Most of this time may have been spent on removing the methane gas. Various estimates of the time this would take have been given. Mr. Metcalfe says 1 or 2 hours, even more. These can only be guesses. The time itself could not run

before the 3 cut-through brattice had been removed. It may never have been removed. Again, this is speculation.

Those who have pressed on me the competence of officials at this mine have argued that Rawcliffe must have tested for methane gas, must have realized his ventilation was blocked and must have found and removed the brattice. This on the surface appears a strong argument. My doubts arise from a number of factors. There appears to have been some intake air flowing up 'B' heading - not enough for ventilation, of course - and Rawcliffe may have been deceived by this. Secondly, I am not overly impressed either by the ability or obedience to proper principles of all officials at this mine. The fact is, as will emerge, that this deputy allowed live electric cables to tun through what must have been a gassy heading. In his presence also an electrician opened a flameproof fan enclosure when the power was on. Thirdly, if the fan starter mechanism in fact ignited the methane gas - I will of course deal with this argument in good time - methane gas had to be near and in the starter box; one source could have been methane gas in 'B' heading outbye the stub, allowed to remain there because the 3 cut-through brattice was still in place at the time of the explosion.

I have dealt in some detail with the evidence of Walsh and Schuster, because it was strongly argued that the panel was not left in a potentially dangerous situation. The corollary of this proposition was that something happened on the following shift which wholly accounted for the explosion. The next step was to attempt to isolate the ignition source from the non-flameproof fan, so that I should be finally unable to say with any degree of certainty either what ignited the methane gas or how the methane gas came to accumulate at all. Thus there would be no chance of blame being allocated to any person or persons.

Recognising the area of concern about the offending brattice, with the consequent accumulation of methane gas, I deliberately made a point of declaring that the Inquiry was "not a witch-hunt", that any allocation of blame was a secondary consideration to finding out what really happened and what could be done to avoid such happenings in the future. This declaration

of intent had little effect. Even after it became abundantly clear that I regarded Schuster's evidence as quite unreliable, I received a report in which the two local Inspectors, Mr. Mould and Mr. Kininmonth (Senior Inspector) joined, assuming on my behalf that I had accepted Schuster's and Walsh's account and declaring that Rawcliffe had received clear instructions to remove the brattice. The attitude of the Inspectors is a matter for some disquiet, but not to be dealt with at this stage. However, the Inquiry could not be led by the nose. A critical approach was necessary at all times.

Having said this, I do not for one moment suggest that either Schuster or Walsh was responsible for the disaster that followed. I have already stressed the fact that there was a substantial time-lapse betwen the change of shift and the explosion. A further examination of what remains of the evidence after the explosion shows that a number of things were done or were omitted to be done which were the conscious actions of those in charge of the new shift. It is true, of course, tha the failure by these men to see the brattice in 3 cut-through removed allowed methane gas to build up in 'B' stub and so the task of the deputy became very difficult, if he appreciated it. There still should have been no explosion.

What the conduct of these two men Walsh and Schuster, illustrates is a lack of knowledge of what was really being done in 'K' Panel. I have already described the planning conference of 18th July, which finally drafted the use of two miners, two fans, the panel preparation for the ventilation changeover and the first main step of this changeover, namely the building of the A3 overcast. Although they did not attend the conference, copies of the minutes were circulated to the assistant undermanagers. The deputies received no copy, but the minutes were posted up for them to read of interested. Mr. Fisher says they were not intended to give details; rather their purpose was to co-ordinate the efforts of those concerned. However, they in fact give some details, but not others. The management according to Mr. Fisher, relied more on oral communication than written documents. Mr. Metcalfe, the Undermanager, takes the same point of view.

This attitude assumes, of course, that those who read are interested, and if interested that they can understand. The management's reply is that they can always ask - there is often frequent discussion between management and deputies. What then of men like Schuster, who did not really demonstrate a knowledge of the ventilation system until his final appearance - leaving out a subsequent reappearance to deal with an entirely different matter? What of Walsh, who did not appreciate the danger of leaving the 3 cut-through brattice standing until the next deputy could reach it, even on his own admission? If Walsh had any real appreciation of what had happened, one would have thought that his duty was to order Schuster to pull down this brattice immediately, instead of catching his transport. Mr. Metcalfe said that he personally explained the plan to the assistant undermanagers. The situation as to the changeover was not so complex. He was sure that they understood it; there had been frequent discussions about it. Yet Mr. Metcalfe was not "particularly happy" about their performance in Court over this very system. He could not explain their apparent lack of knowledge. Mr. McAlpine claims he was probably present at the planning conference of 18th July - in fact he attended such meetings once a week, probably an overstatement, (on Mr. Fisher's evidence). He had discussed the new 3-heading system and the changeover with Mr. Metcalfe many times. The reason for having 2 returns, he said, was to give better ventilation with less resistance. This was common knowledge. Not a word came from this expert, on whom the management was relying, about changing 'B' heading from intake to return to avoid methane gas contamination from the longwall of coal - its prime purpose, according to Mr. Fisher.

What I am stressing highlights an old problem, of course. There is always a tendency for those who issue instructions to believe that those who obey them are in as good a position as themselves in understading the instructions. There was a grave communication problem at Appin even though it only came to the surface at odd occasions. It was not good enough to believe that all persons concerned understood the changeover of the steps needed to bring it about. Schuster and Walsh are really victims of this error.

They were also victims of their own belief that they understood - either that or they were too proud to ask questions and so betray their lack of knowledge. Both men were obviously hard-working, willing servants. The importance of their work needed greater explanation for their benefit. It is important that they not be misjudged and that their failure should be put into correct perspective.

The actual plan for the use of two fans did not receive the approval of the Department before the changeover system began. The rule is that the Department does not approve of a ventilation system; however, it does not allow a change of fan system to be put into operation without overseeing the whole system of working in the place where the fan is to be used. It is customary to set out drivages in order and the consequent changes in fan position, together with stoppings and similar details. Mr. Fisher says that he had already discussed the plan in some detail with Mr. Mould, the Inspector, who had agreed in principle with the scheme, and waited for a visit from the Inspector and Mr. Kininmonth concerning another matter, planned for 24th July, the day of the explosion, when he would hand the drawn plan over to Mr. Mould. The explosion intervened. Mr. Mould reminded him then that there was no application from the colliery and Mr. Fisher produced it.

The Departmental attitude, I was told, was that the plan would have been approved. Mr. Fisher denied that he handed the plan over to make good an omission; it had always been his intention to do so. However, failure to have an approved plan meant that no such copy plan could be posted on notice-boards for officials or men to see. The previous plan, a 2-heading plan had been so posted. I am puzzled as to why the changeover was started before fan approval, even though Mr. Mould may have indicated approval would be forthcoming. It is a matter of incidental interest that the 'B' heading stopping outbye 3 cut-through is marked as a brattice stopping and placed closer to 2 cut-through. In fact the evidence is that this was to be a plasterboard stopping, located in the same position. Plasterboard had been delivered for this purpose to the panel.

A consideration of the institution of the ventilation changeover gives one a feeling that its timing was a haphazard affair. Although I was told that it had been planned for 24th July, no specific shift was decided upon. Of course, the preparation work could be started on one shift, and completion left for another. It appeared to be a last minute decision that it commence, at least, on the afternoon shift. Possibly predictability could not be more accurate than this. Firstly, it depended on the completion of the overcast, which was somewhere near completion earlier on 24th July. Secondly, it should have been dependent upon the provision of enough air in the headings to run a second fan. It was claimed by Mr. Metcalfe and others that this quantity of air was available on 23rd July. This proposition needs separate discussion. However, timing of the last steps was crucial.

A piece of evidence by Mr. J. Christ leaves me sceptical and uneasy. Christ was the man in charge of the building of the overcast. I have already referred to his account of Walsh's statement to him that when the overcast was finished Schuster on his instructions was to erect the brattice stopping in 'B' heading and pull down the stopping between 'A' heading and Longwall 8 maingate. At the same time, according the Christ, Walsh gave him no instructions to let Schuster know when the overcast was finished. I considered this strange evidence - a piece of information alleged to have passed from an assistant undermanager to a workman with a single purpose in mind. Be that as it may, Christ says that he told Walsh that the overcast was finished, not Schuster whom he saw in the crib room on the way out. This was between 6.15 pm and 6.30 pm. He happened to see Walsh on the way out, at about 6.45 pm - he thinks he went by transport, but is not sure - he thinks it was in White Panel track road going towards 'K'. Walsh said not a word in reply. According to Walsh, Christ was to let Schuster know when he was finished - in fact, this was part of the alleged instruction he gave to Schuster via Christ, which he says Schuster repeated to him so that there could be no mistake. Walsh in fact left the panel at about the time Christ says he spoke to him. But by 6.50 pm, according to Walsh, he was in control speaking to Oldcorn on the telephone.

Perhaps Christ has had a lapse of memory about a number of things. For example, he failed to tell the Court that his overcast had certain bricks missing, and this was revealed by a later witness. The holes so formed were left plugged with brattice. Christ used this as an excuse for not revealing the fact. He says he was to come back next day when his overcast was in operation to check for leaks. However, there is one part of his evidence which cannot be accounted for by a lapse of memory. He told the Court that he could not remember which route he took going out. He could have gone inbye from 3 cut-through and proceeded via Longwall 8 maingate outbye or down 'A' heading towards the crib room, which was located in that heading. Alternatively, since there should have been no stopping in 'B' heading, he could have turned straight down that heading from 3 cut-through and gone outbye. At some stage he ;must have reached 'A' heading, because he saw Schuster in the crib room.

He, Christ, was recalled to the witness-box almost a week later and this time he was shown a statement he had made to Inspector Rose. In that statement he had told the Inspector that when he finished he walked from 3 cut-through into 'B' heading and then inbye to 4 intersection, without going into 4 cut-through. He said he had done this to check the airflow (which could not possibly have been changed by his overcast). He •protested that he still could not recall his movements even though he had made this clear statement. He added in his statement that he noted that the air was flowing inbye to 4 intersection. His explanation in Court was that since there was no stopping in 'B' heading that was the only way for intake air to go. He then gave two explanations. The first was that he had gone for a "bit of sticky-beak". The second was that he might have gone round that area to start walking in 'A' heading, but he could not remember. After he looked at his statement again, he made a number of vague statements and said he had no answer. It was then put to him that the reason he went to check the airflow inbye was because by that time the brattice stopping in 'B' heading had already been put up. He denied this.

In any hearing it is customary for witnesses to give conflicting evidence quite honestly. Memory

for events necessarily fades and in any case a witness makes mistakes. One must make full allowance for this sort of thing when assessing the credibility of any witness. The memory of witnesses in this Inquiry, however, should not have been gravely defective when what they were describing had occurred a few hours before the explosion and particularly if it was relevant to the explosion. It must be remembered that during the day of 24th July the disaster which had just happened brought horror to the local mining community. Those who had worked the shifts before the explosion were searching for possible causes and recalling such events as they knew about. Discussion during the days that followed was at its height. The memory of their possible earlier part in the disaster that occurred in the evening shift would not easily be lost by witnesses. Further, Christ was adamant that he did not tell Schuster he had finished.

It is partly for this reason that I have felt a serious disquiet while hearing and later reviewing that has fallen from some witnesses. Christ is one of these. He is probably a minor witness. In itself his evidence is not so important. What it may indicate is very important. There seems to have been something to hide at this Inquiry. No one man can decide to hide it without the agreement of others who may be witnesses. These mcn, ordinary working men, if they wish to put their heads together, are not very good at it. An exposure of an inconsistency in their evidence leaves them with no answer except the weak crutch of a failing memory. There were a number of occasions throughout the Inquiry when I felt that I was not viewing the entire picture. There seemed to be gaps in the evidence that could have been called, and it was not the fault of Counsel assisting the Inquiry that it was not called. It was because its existence was not revealed. I would have thought that miner-drivers and machine men could have told me more about methane gas conditions at Appin. I heard from no miner-driver - or machine man. I thought that the Federation's witnesses were curiously absent, despite the excellent assistance given to me by their representative, Mr. Ohlsen. I finally fear that in this case there may have been another example of what I have experienced before - the loyalty of one mining man to

all others, even his superiors, to ward off the intruder. Yet, I was told in evidence that behind the scenes there were men accusing each other. In another Inquiry, which I am conducting at the time of writing this Report, the principle has been described to me on oath by mining men - the refusal to "dob another man in", as it is called by the men in that mine. However, I cannot come to any conclusion that Christ's evidence is false. I merely say that he leaves me uneasy and suspicious.

All witnesses were keen to leave me with the impression that officials such as deputies invariably followed correct procedures and were particularly careful about testing for methane gas and avoiding dangerous accumulations. So it was that early in the Inquiry Counsel, obviously on instructions, were prone to ask questions tending to show not only that Oldcorn and Rawcliffe were expert and trained officials - which I was ready to accept - but that neither man would do an act outside the course of his duty, or anything which was dangerous or forbidden by the Act. I put a stop to this practice at an early stage on the ground that it had no evidentiary value in discovering what either unfortunate man had actually done on the vital shift.

Evidence was called, however, not touching directly either of the two officials, which put an end to the fallacy that all deputies and as0.stant undermanagers always did their duty at Appin. This came through the calling of Inspector Mould, who had inspected 'K' Panel 3 times before 24th July over a period of months. These were unannounced inspections and recorded by him officially for his own purposes. The results are quite disturbing.

The first of these inspections was on 12th February, 1979. A second heading was being driven with the use of a miner and one Richardson fan (the type used at the time of the explosion). The Inspector was accompanied by Mr. R. Moore, Deputy Manager and Mr. W. N. Gow (designation unstated). The total quantity of available air was stated to be 33,000 cu. ft. per minute and at the work place 15,000 cu. ft. per minute. Among the methane percentages in intake airways the Inspector found the following: 0.4% in the intake cut-through and 0.8% outbye the miner in the intake. The Act

prescribes a limit in such intake airways of 0.25%, excepting for short periods, requiring the Inspector to take an average of samples over an interval of not less than a fortnight when the average must be not more than the prescribed limit of 0.25%. There is, incidentally, no evidence that the Inspector re-visited the mine to take his average sample. Nor is there any evidence that the mine had been exemptefrom this provision by the Chief Inspector.

At the time the miner was not operating as it had been stopped for methane gas. How long it had been stopped or what the men were doing is not made clear. The methane gas was being cleared by the vent tube, so that the fan was on. It is not stated how far the fan was located from the methane gas. But the Inspector found 3% of layered methane gas above the tube under the roof. There was also 3% in the top of the tube, which would have to pass through the live fan. The Inspector notes that "this panel has almost reached the limit with one fan". Presumably what was desirable was a system of two fans in parallel joined ultimately to the one vent tube. He says "another is to be installed as soon as one becomes available from Red Panel, after holing there". It has been established at the Inquiry that one Richardson fan on open circuit (that is, without vent tubes) draws close to 20,000 cu. ft. per minute. The necessary air for it to work without recirculation is that quantity plus an additional 30%. Otherwise re-circulation of the contaminated air which it draws tends to take place. At that time, however, the manager believed, on maker's specifications that the fan drew only 18, 000 cu. ft. per minute. Safe operation would then require 23,400 cu. ft. per minute. However, the addition of another fan in parallel would substantially alter this calculation. It would not double the air necessary as in the two separate fan systems to be used with the 3-heading two-miner operation of 'K' Panel at 24th July. The formula is more complicated than that. However, nowhere does the Inspector even raise the question of whether extra air will either be necessary or forthcoming.

The question turns out to be largely academic. Inspector Mould next visited 'K' Panel on 5th April. He was then accompanied by Mr. Fisher, the Manager.

Only one fan was still available. The total quantity of available air was measured at 21,000 cu. ft. per minute which Mr. Mould describes as "only just enough. Very sluggish flow past fan, but no recirculation". If fact it was obviously not enough on the accepted figures. He received a promise, however, for he says it was intended to increase ventilation on the following weekend by air redistribution of air elsewhere. Why the quantity in 'K' Panel had been reduced is not even mentioned, let alone made clear.

There is an explanation, however, as to why the second fan has not been installed almost 2 months after his first inspection. It is still in Red Panel, which will stop at the weekend, making the fan available for 'K' Panel. Mr. Mould found what he described as an unsatisfactory methane gas situation. He obtained readings of 1.2% in the general body of the return, 1% at the fan, 0.7% outbye the miner, 0.8% at the roof over the miner, and $1^{1}/_{2}$% to 2% at the roof on the face. Airborne dust was described as only just satisfactory. But the surprising statement is that the high methane gas concentration at the face was cleared by extending the vent tubes. Before the visit, the deputy had been in charge. One is forced to ask why this simple measure had not already been taken. Apparently the miner was working, or at least power was on, for the machine monitor is described as "now O.K. reading 0.9%". We are referred back to the report of 12th February when it was shown to be reading high.

By the time of his third visit on 13th July, Mr. Mould found that 'K' Panel was being driven as a 3-heading panel. There was still only one fan, and he was told that another fan would be introduced in parallel. He remarked that there was only just enough air to keep the gas down, although the quantity had been increased to 41,000 cu. ft. per minute total with 14,000 cu. ft. per minute at the working place. In fact the miner had actually stopped, apparently because of methane gas. There was a 4% layer at the roof. Mr. Mould directed that the vent tube be extended and that a venturi be used. This dispersed the layer and the general body percentage was read at 0.8%. There was 0.6% in the nearest outbye cut-through on intake.

Nowhere do we hear of what reasons for these conditions were given by the officials accompanying Mr. Mould to the Inspector. Nowhere do we receive an account of what followed the visit by way of reprimand or instruction to the deputy. These, of course, were three chance visits - it would be folly to assume that they were isolated occasions. Promises as to an extra fan were given to Mr. Mould in February, yet by July it had not arrived. Mr. Mould does not tell us of what he said.

It is a reasonable assumption that these conditions were quite usual in 'K' Panel. When Mr. Fisher speaks of increasing difficulties with methane gas, it is this sort of thing about which he must be talking. Mr. Metcalfe describes the position in a number of ways. He is asked whether the position before the explosion as reflected in the deputies' reports was a healthy one for the Panel. He replies, "Yes, I would think so. Under our circumstances, yes". He is reminded that this might not mean that the condition was safe. He replies that he does not know if he meant to imply that it was unsafe. "Certainly, we were coping as best we could, to my ability". Finally, he says that the deputies were only telling them something they already knew about. He maintains, however, that the methane position in 'B' stub was capable of being dealt with if the brattice had been maintained in a satisfactory condition at all times. The evidence is abundantly clear that it was faulty until the end of the pre-explosion shift. The last thing Schuster did was to attempt to repair it. He left it unrepaired and, according to him, reported that fact to Rawcliffe.

One cannot escape the inference that methane gas was tolerated in this mine unless it was believed to be dangerous. I do not for one moment suggest that coal was cut in the presence of high concentrations of methane gas. Apart from monitors to prevent this, the officials at Appin were far more conscientious and able than that. What was in fact allowed to happen was the growth of a philosophical attitude towards methane as a fact of life. It was a nuisance, it could hold up production in working places, but it was not a matter of great concern in standing places where the possibility of ignition was remote. The officials had their own view of when methane gas was permissible. It differed from the standard of the Act.

Even Inspector Mould tolerated it. Without wishing to appear over-critical I must say that I find it inexplicable that a visiting Inspector has to direct the removal of a methane gas accumulation by the extension of vent tubes, or that he is prepared to accept promises over a period of months as to an improved system of ventilation. In fact Mr. Mould agrees that the Act has been allowed to be breached in gassy collieries. He says that he has always worked to methane figures of 0.5% to 0.8% 100 metres back on the intake side. The 0.25% in the Act, according to him, is "not practical" for collieries like Appin. He understands that other Inspectors follow the same trend. The rationale for condoning a continual breaking of the law is that "the new Act" contains the same figures.

In fact, of course, there is no new Act. Proposals for an amended Act have reached conference and draft stage. As I write, the "third draft" has recently become available and is the subject of deep controversy. There is considerable opposition on safety grounds from certain bodies to a lifting of these methane percentages. Mr. Kininmonth in evidence thought there should be a change, but for different reasons. He said that mining and ventilation methods had changed, so that higher intake figures could still allow safe figures of methane at the face. In any case, he thought the figures cited by Mr. Mould were too high.

The presumption by an Inspector or group of Inspectors that they were in a position to tolerate continual breaches of the law astounded me. I hasten to say that the Minister and Undersecretary were quick through Counsel to deny any knowledge of the practice and to dissociate themselves from it. Since that time I have received a document from Inspectors in the Department who are not coal mining Inspectors and are appointed under different legislation. They wish me to make it clear that they should in no way be confused with those Inspectors whose duty it is to enforce the Coal Mines Regulation Act. However, Mr. Mould attempted to qualify his position. He said he was not talking of the policy of the Department, but that he understood that the Department knew what was happening and that he had not been given contrary instructions. Yet earlier, he is recorded as saying "It is just not me, it is part of the policy of the Department too".

I do not intend to become involved in any problem of semantics, however. Mr. Mould goes on to say that the Department would not allow any such tolerances if the levels at the face were not safe. I do not know how Mr. Mould or his associates enforce this provision or envisage how the "new Act" is to enforce it. Certainly Mr. Mould could not have considered the percentages he found in his visits to Appin to be safe, even though coaling may have stopped, or he would not have gone to the trouble of showing the officials the simple methods of removing the methane gas. What chance is there of properly ventilating the face with methane contaminated air from intake airways?

However, two inferences emerge from Mr. Mould's evidence. Firstly, those at Appin Mine could expect their breaches, at least as to methane gas and ventilation to be treated tolerantly by the Inspector. His method of policing the Act appears to have been by friendly advice rather than by strict action. Secondly, despite any story I have been told about the efficiency of mine officials, a number of them either did not bother to remove methane gas or did not test for it.

The definition of what is dangerous really is the test of whether methane gas levels were acceptable. Obvious sources of ignition in general, one supposes, would be kept away, if high enough levels were found. But the attitude of Vasak, the deputy, that all methane gas is dangerous, was by no means universally shared. What may have been excepted was the provision in the Act, for $2^{1}/_{2}\%$ to be present in the general body of the air, before men must be withdrawn (G.R.7), was regarded as the only test of when methane gas is dangerous. The management simply thought that the conditions under which they were mining rendered methane gas in quantity unavoidable. The real danger was not appreciated - that ignition could come from an unexpected source. One could never, of course, say that mine officials or men were completely oblivious of chance ignitions. But the coming together of two factors - a collection of methane gas and a chance ignition source, appears to have either been forgotten or accepted as a risk to be taken. I do not think this is too sweeping a statement, although there obviously were many parts of the mine almost entirely free of methane gas.

Otherwise one cannot possibly account for what Mr. Mould found on 3 visits over a period of some 5 months to the new area being developed. It would be ludicrous to say that is was merely coincidental that he found what has been described on each visit, and that everything was safe between his visits.

If any more support for this view is needed, it is to be found in the mine's attitude to methane levels in its return airways. We are dealing with General Rules 7 and 24 of the Act, both of which involve conditions in airways.

General Rule 7 provides, inter alia, that if at any time any part of a mine is found to be dangerous because of inflammable gas, every workman shall be withdrawn from that part of the mine, and that a competent person shall inspect that part for gas and shall make a true report of the condition of that part, no workman being allowed to return until the part has been found not dangerous, etc.

I interpolate to say that "part of the mine" is not limited to the airway to be inspected. It must refer at least to the whole district.

Reports are to be signed and recorded in a book. The place is deemed to be dangerous if the place is found to contain in the general body of the air $2^{1}/_{2}\%$ methane gas or upwards.

General Rule 24 provides that every main return airway which is not ordinarily used for travelling shall be maintained in a safe condition for travelling, and that a deputy shall travel the whole air-way at least once a week and report the conditions as to ventilation and general safety, which report shall be signed and kept, etc.

Aparently on 11th May, 1979 Inspector Mould and Mr. Fisher inspected the Main Longwall Returns and North East Returns. As a result, Inspector Mould was constrained to write to Mr. Fisher by letter date 14th May. He drew attention to the fact that:

(1) Over $2^{1}/_{2}\%$ methane was detected along the major part of the three main return airways.

(2) Over 3% methane was detected at the methane monitor at the inbye end of North East Returns.

(3) The deputies' reports under General Rule 24 contained no references to any unsatisfactory situation.

(4) There were no deputies' reports under General Rule 7 stating that a dangerous condition existed.

In Inspector Mould's view the airways and the monitor could not now be inspected and workmen must be withdrawn until such time that safe conditions were restored. He then sought information as to the action proposed.

It appeared, however, that measures had already been discussed between them, and the letter was a documentation of the inspection results.

Mr. Fisher replied a fortnight later. He said that the colliery also was extremely concerned and referred to a meeting which had discussed the management's intention. Mr. Kininmonth and Mr. Carthew, Superintendent of Collieries, had been present. He described these measures, which, incidentally, included ventilation changes in TE' Panel and a methane drainage feasibility study.

Then Mr. Fisher defends the colliery in regard to the apparent breaches of the rules. As to General Rule 7, he says that there were no people working in the section and therefore none withdrawn and it had not been thought necessary to carry out any inspections of the returns. Apparently the management believed that fire and/or explosions would not travel down headings to other parts of the mine. But more significantly, it believed it could ignore a categorical General Rule of the Act which dealt specifically not only with the safety of inflammable gas in a part of the mine, but with the reporting of it. In effect, the colliery decided that any level of methane in the main longwall returns was not worth worrying about.

In regard to the breach of General Rule 24 he said:

(a) the standard report form does not specifically ask for "noxious or inflammable gas" - the Rule in fact refers to "ventilation and general safety".

(b) In reply to the question "State of ventilation" the report had said "fair", which meant "less than satisfactory", but was nevertheless, "insufficiently specific".

The letter went on to speak of further measures to be taken, and to deny that the colliery had ever taken the methane gas problem lightly. It does not, of course, explain how any deputy can refer to ventilation in a return airway as "fair", when that airway contains $2^{1}/_{2}\%$ or more of methane.

For the sake of completeness I should record that on 8th June the Manager applied for exemption from the General Rules in relation to the district and main return airways from the Longwall 6 district. He had already discussed this with the Chief Inspector. He referred to the efforts to increase the quantity of ventilation and the work undertaken to keep at least one roadway safe for travelling and to allow proper inspection. He also referred again to the feasibility study in relation to methane drainage. This exemption was granted on strict conditions on 16th July, the Minister saying that the quantities of methane being liberated in the colliery were giving him cause for considerable concern.

I have dealt in some detail with this topic in order to demonstrate the Colliery's previous attitude towards methane. I am satisfied that that attitude has now changed. The policy in regard to methane drainage, practised elsewhere both here (on a very limited scale) and abroad to a far greater extent gives clear demonstration of the colliery's seriousness in tackling its most serious problem. I feel certain that with its record for expertise and its high technological skill, it will succeed in providing a safe system which will prove an example to other collieries. It has already received much encouragement and advice from Mr. Mould, who has done some research on the subject abroad. What is true in other strata as to methane extraction from solids, may not of course, be true for Appin and the special feasibility studies it is engaged in therefore assume special significance. It is to be hoped that the Department gives Appin Colliery whatever assistance is at its disposal in this field.

I should refer to another practice which received substantial attention by Counsel during the Inquiry, but now seems to have little direct bearing on the explosion. During Ashelford's shift there was trouble with the Marietta miner, in that the methane

monitor on the machine gave a high reading in 'A' stub and kept tripping power off the miner, halting production. The monitor in this case is a safety device to prevent coal being mined at high levels of methane gas. It is electrical in operation and methane gas is detected on sensing heads. Apart from the monitor the miner driver must in any case check for methane gas at the face with his safety lamp at regular intervals, preferably after each car load of coal. It is possible to put the monitor into defeat, thus preventing it from tripping out the miner, enabling coal to be cut, despite the monitor-reading. McAlpine, the assistant under-manager on the shift had spoken to Vasak, the previous deputy, who had told him that the monitor was "playing up". On his own inspection the miner was working and the reading on McAlpine's methanometer was .7%, but the machine monitor read high at 1.2%, not high enough, however, to trip out the miner.

The deputy on the next shift, O'Connell, discovered that the miner driver could not put power onto the machine, because the monitor tripped the machine on high alarm, that is, 2%. There was no methane gas at the face. A red light came on. O'Connell pressed the re-set button, the monitor read 1.2% and power came back on. The monitor usually trips at about 1.8% to 2%. Of course, there could have been some methane gas, but O'Connell's lamp would not detect a level below 1.25%. Yet the monitor had been tripping at 1.2% and was obviously faulty. Later in the shift the monitor kept tripping the miner while it was tramming and while the driver was trying to start the picks. O'Connell checked for methane gas again and found none. He decided that the monitor was faulty and put it into defeat. The miner went on working without a monitor.

Walsh, the assistant-undermanager, tested the monitor also and, left it in the defeat position. The repairing or replacing of a faulty monitor is apparently a frequent occurrence and involves work by a competent electrician. It may be repairable underground, but often has to be taken to the surface. Walsh tried to obtain Kierce, the electrician, to look at it. Kierce confirms that Walsh had asked him to look at it if he had the chance. He was busy attending to the electrical work for the ventilation changeover. Ususally, he said, a

replacement had to be brought in. Kierce said he knew that a miner could not be run indefinitely with the monitor in defeat. General knowledge in the mine was that it could be run up to 24 hours. He denied that the practice was to stop working the miner without a monitor at the end of the next succeeding shift. Mr. Reed, the Chief Electrical Engineer, placed the period of grace until the end of the next shift, which he calculated somehow at about 12 hours.

The only relevance of this discussion is that the colliery officials in charge, with the concurrence of the miner-driver, would at any time when there was a high methane gas level, be able to put the monitor in defeat and keep production going. I know of no evidence that this happened at Appin and I do not say that it occurred in fact. Yet the Colliery in correspondence with the Chief Inspector was reluctant to sacrifice the principle that it could go on mining for a limited period with a faulty monitor. In January, 1979 a new set of rules reached the Manager over the Chief Inspector's signature, relating to "Automatic Monitoring Devices". Inter alia it provided that the trip over-ride button or switch shall not be operated unless:

(a) The monitor has been shown to be inoperative or it is covered by provisions re testing, repairing, etc.

(b) A record of the time of failure and the time when the monitor was again operational shall be recorded in the General Rule 4 shift report book and other records.

(c) The over-ride device shall not be used in normal coal winning operations.

On this occasion the Company's Superintendent of Collieries replied, assuming that previous approvals granted for its monitoring devices, being specific approvals, would take precedence and continue to be effective. He also accepted that where the automatic monitoring device is over-ridden as in paragraphs (a) and (b), this could not be taken to be "normal coal winning operations" as in paragraph (c).

The letter sought an appointment for discussions. There was no reply until after the Inquiry started. By letter dated 26th October, the Chief

Inspector politely apologised and said he had been waiting for an approach for an interview. He rejected, however, the Company's submissions.

I have dealt with this matter in some detail because it appeared important to the parties at the time; I do not wish it to be said that I overlooked the issue, which now appears to be settled.

THE IGNITION

There is only one way to determine what caused the body of methane gas in 'B' heading stub to ignite. The condition of the heading and what it contained must be examined together with any evidence from witnesses who saw victims during the shift. Of the two sets of circumstances the latter is interesting, but standing alone, it is equivocal - it may be helpful in conjunction with other evidence. The evidence of what was found is incontrovertible, but the inferences to be drawn have been the subject of great controversy. I deal with these first.

The 'B' heading stub itself was some 70 metres long. According to a number of witnesses this made its ventilation on brattice most difficult. The line of brattice had disappeared in the explosion. Yet there was a rolled-up piece of brattice in 4 cut-through between 'A' and 'B' stubs which was the correct length to fit from the entrance to the stub across 4 cut-through, where the original brattice had extended. It was believed that this part of the brattice had been removed by the deputy, Rawcliffe, prior to the explosion, at the commencement of fan ventilation of the stub. Although strictly this does not necessarily follow, I think this is the most probable explanation for this brattice. There were no other rolls or extensive pieces of loose brattice.

The Joy 10CM miner was just inbye 'B' stub, its boom extending into the cut-through. A few metres back from this in the cut-through was the shuttle car outbye (A.I.S. No. 62) which extended a few metres past the corner of 4 cut-through and 'B' heading. This contained, as I have indicated, a coil of apparently spare cable piled in the traditional figure 8 pattern, and wedged under the top coils was the body of Rawcliffe, head facing inbye, together with his safety lamp. His belt

and other accoutrements were in the car also, but there is some doubt as to whether they had been removed afterwards and placed there. The miner cable extended for some substantial distance beyond the miner inbye the stub. It was damaged. The shuttle car cable was also damaged. The body of Brewin was in the centre of 'B' heading proper, further outbye, and a short distance from the last known position of the 'B' heading fan. Behind some steels near the right hand rib looking outbye was the body of Oldcorn, his safety lamp almost intact, his methanometer much further inbye.

Some 23 - 25 metres outbye from its original position was the 'B' heading auxiliary fan, part of its cable still attached having been severed some 14 metres from the fan, and lying on its side. It weighs almost 1 ton. The fan starter box was exposed. It was found to be in a non-flameproof condition. Its hinged rear door, fitted with 24 holes for studs to be screwed against the metal flange around the opening of the box, contained one stud only, screwed for 2 threads. 14 of the missing bolts or studs from the fan were located nearby. Afterwards 2 more were found under dust and debris during a special search for them organised weeks later. The remainder have not been found.

Amongst the debris there were found the remains of destroyed vent-tubing, a piece of safety lamp glass, electrician's and other tools, a multimeter, various pieces of brattice and the like.

The search was meticulous. Every item which was suspect in that it could have ignited the methane gas was examined and tested at the Londonderry Testing Centre and elsewhere, and is the subject of its own report.

Electrical equipment, which is notorious for being the source of an incendive spark, was examined as follows, with the consequent results:

All miners' caplamps are powered by battery. Some of these had suffered varying damage. They all substantially complied with Approval conditions, although there were instances of standards not being maintained. These were all eliminated from suspicion.

An insulated screwdriver , apparently used in electrical equipment, broken and burnt. It was decided that the damage had occurred before the

explosion, the screwdriver having been used to provide leverage. There was the sign of arcing. The screwdriver was eliminated.

The machine mounted methane monitor used on the continuous miner. The housing assembly was found to be in flameproof condition. The sensing element had been removed - it was found scattered down the heading. Although there was burning, there were no electrical faults likely to make the system unsafe. This was also eliminated from suspicion.

A Taiheiyo radio transceiver in the possession of Mr. Oldcorn was found in 'B' heading. Its examination revealed no electrical faults. It had been approved by the Department prior to its use as intrinsically safe, but an on-off unapproved toggle switch had been mounted on the bottom by A.I.S. steelworks' electronic department. This did not alter the examiner's opinion that it should be regarded as free from suspicion.

A portable electrician's multimeter for measuring of voltages, current and resistance was found severely damaged and in pieces at various locations in 'B' heading. This is not an approved instrument for use in mines. It is powered by 2 size AA batteries, found in 'B' heading approximately 55 metres outbye B4 intersection. These were found to be mechanically damaged and the casing had been burnt. An examination of the moving coil and the wiring showed no evidence of arcing. It was compared with other multimeters and was found to be intrinsically safe. It is not suspected.

An Auer methanometer for testing of methane/air mixtures carried by Mr. Oldcorn was found by Mr. Kininmonth in 'B' heading some 20 metres outbye the final resting place of the fan. It had suffered severe mechanical damage to its casing and carrying case and its internal electronic system. It was examined for signs of arcing, component damage and circuit modification. It was compared with similar methanometers.

A series of methanometers was used for testing with a 7.8% ethylene/air mixture. In the first test the actual methanometer was supplied with 4.5 volts from an external power supply. This was connected to various places of the methanometer circuitry. In each test there was no ignition of the methane gas mixture. After each

test a control test was performed to show that the mixture was satisfactory by igniting it with a test current.

In the second series of tests another Auer methanometer was used, without igniting the mixture.

In all there were either six single tests or series of tests for the methanometer. Mr. K. Fisher, Electrical Inspector of Collieries, was subjected to rigorous cross-examination, on his description of the tests as "exhaustive". He was described in one Counsel's address as being young and inexperienced. In the early stages of the Inquiry some Counsel appeared to favour the methanometer over other sources of ignition. The position altered as the Inquiry progressed. However, it was still advocated as a really possible cause by one Counsel. Mr. Fisher was supported by Mr. Lloyd, Director of the Centre and an experienced, formidable expert. I have no hesitation in accepting the validity of Mr. Fisher's research, experiments and conclusions. As far as I am concerned, the methanometer could not possibly have ignited the collection of methane in the stub. Appart from the scientific tests, however, I should say that the circumstances support Mr. Fisher's finding. On the unquestionable assumption that the explosion commenced at the inbye end of the stub, I have not been able to discover any evidence of a conceivable flamepath from the methanometer to the methane gas at that end.

The 'B' heading fan motor, as distinct from the fan starter, was examined to test whether an inflammable gas/air mixture inside could cause an explosion in an explosive gas/air mixture externally. The interior was filled with a 6% mixture and placed in a test chamber filled with an 8.3% mixture. The internal gas was then exploded with a fitted spark-plug. The external atmosphere was not ignited. A subsequent control test using independent means ignited it. With the motor stopped the test was repeated with a similar result. The motor was also examined and subjected to insulation resistance tests. A visual examination supported the finding - that the fan motor was no longer worthy of suspicion.

I pause to deal briefly with the subject of contraband. Although some unused matches were found a

considerable distance from the explosion site by Mr. O'Connell, everybody agreed that they could not possibly have exploded the methane gas. The policy with regard to contraband at Appin mine is very strict. Not only does the management carry out random checks and searches, but the Federation men take the sternest measures against any member found to be breaching the law.

I propose to deal now with the 3 cables concerned, the fan cable, the shuttle car cable and the miner cable. Normally an unenergized cable is beyond suspicion as a source of ignition. However, the electrical experts are adamant that all 3 had been energized and damaged and therefore they had to be investigated. It is essential to the finding that power was on to all 3 machines, that some part of the mine's electrical system be described.

(i) Distribution of Electrical Supply and Electrical Equipment

Electricity is supplied underground from a surface substation at 6600 volts. The main mine equipment operates on two voltages - 1000V and 415V. Lower voltages operate control, lighting, signalling and communication.

°K' Panel's sub-station is in the crib room at 6600V via a mains power cable and an isolating switch for the district. The individual pieces of equipment are not subject to isolation. The crib room has two transformers, a 400 KVA 6600V/415V to supply the 415V equipment via load centre No. 38 and a 500 KVA 6600V to supply the two miners. The decision to change the ventilation system necessitated an additional auxiliary fan for °B' heading. This meant the siting of an additional 415V reticulation supply cable from the transformer in the crib room to an additional load centre No. 30 sited at the A4 intersection. The °B' heading shuttle car (No. 62) was also supplied from this load centre.

Both miners, the Marietta in 'A' heading and the Joy in °Br heading had already been coupled to the 1000V transformer by the beginning of the afternoon shift on 24th July. The °A' heading shuttle car and fan were already operating from their load centre, (that is, the gate end box) No. 38. During that shift the 415V reticulation cables were recovered from 'B' heading and

run out in 'A; heading from the transformer in the crib room to load centre No. 30. These were not coupled through or hung or connected to any equipment. The work was left for the next shift (the explosion shift) to complete. It was estimated by the electricians who gave evidence that the work, using assistance from Federation men, would take at least 2 hours to complete.

(ii) Observations of Equipment after the Explosion

The coupling of cables and the power supply to load centre No. 30 were found to have been established on inspection after the explosion. Inspector Caulton, Electrical Inspector of Collieries, has made extensive inspections and has reported on the post-explosion situation, both as to power supply and equipment. He found that both the °B' heading fan and shuttle car (No. 62) had been supplied from load centre No. 30. No 38 load centre supplied the 415V equipment for °A' heading, namely the fan, the shuttle car and the ratio feeder.

The power supply at the colliery is provided with a flag tripping device at the surface which effectively puts off power to the underground on fault in the supply system. At 11.00 pm. the surface tripping device put off all power underground at the same time. The main fan was not stopped. The switch had tripped on instantaneous over-current, earth leakage and fan failure relay. Mr. Caulton says that the failure could have been the result of the explosion disturbing the airflow, or a dip in the voltage caused by a fall coming on the cable underground. An inspection of the 6600V cable underground showed that the interconnecting cable between the two transformers had been seriously damaged - including the near-breaking off of one cable end. This was sufficient to cause the surface portection trip to operate.

The 6600/415V transformer looked as if it had been in an explosion, with doors blown off and soot and dust deposited around and in enclosures. The 415V transformer's earth leakage relay was in a tripped condition. The system at Appin had no individual circuit breakers for each individual circuit. If there was an earth leakage fault in any circuit, for example the fan cable, the trip would occur at the transformer and 415V power would stop on all equipment using it in the district.

Mr. Caulton says it is impossible to give the actual cause of this tripping since the sequence of events cannot be determined. He lists the likely causes, any of which, if it had occurred first, would have caused the trip at the transformer. These are:

(1) Damage caused to reticulation cables in 'A' heading by the roof fall.

(2) Damage to the shuttle car cable prior to the explosion.

(3) Damage to the shuttle car cable after the explosion.

(4) Damage to the fan cable after the explosion.

The reticulation cables were those in 'A' heading. They had been connected to the 'T' pieces and the cables were broken off and the ends pulled out. In several places they had been under falls.

The 'A' heading Marietta pilot switch was in the "run" position, showing that power was most likely on to it. Its circuit was not tripped. The 'B' heading Joy 10 miner's protective devices had tripped and its cable was damaged. Power must have been on to that miner also. Strangely, the self-latching stop button on the circuit was found in the 'off' position. It could not have been off at the time of the circuit-trip or there was no way in which the trip would have operated. Inspector Caulton came to the conclusion that the button may have been hit by flying object or it had been accidentally depressed by the rescue team when the members put a table on top of that transformer. There is no other conclusion, however, than that the button was depressed after the circuit tripped out. Furthermore the switch that controls the power to the miner from the transformer was in the "on" or "run" position. This cannot be left in that position and power turned on later. It can only be switched on by a deliberate act. The light switch was also in the "on" position. It would seem unlikely that both of these switches - there is a switch between them could have come on by accident.

The cable supplying the miner was coupled by back to back coupler near the junction of 4 cut-through and 'B' heading. From that coupler the cable was 149 metres in length. It was looped inbye the miner in the 'B' stub and then back to the miner where it plugged into the miner receptacle.

(iii) Testing of the Cables

The 3 damaged cables were transported to the Londonderry Testing Centre for closer expert examination. A report on each by Mr. K. J. Fisher was prepared and discloses the following situation, the examination was conducted in the presence of Mr. Caulton and Mr. L. Robinson of the Company which manufactured the cable. The cable was enclosed in a heavy duty outer sheath. Inside the sheath were 3 insulated power conductors individually screened in metal, the screens being used as earth conductors. There were also 3 covered pilot conductors corresponding to the main conductors.

The outer sheath was intact but had suffered damage at numerous locations. Each conductor was tested and found to be electrically continuous, indicating that the cable had not been severed or subjected to tension which broke any conductor. However, the blue phase conductor was short circuited to earth. A break test indicated that the fault was located at approximately 59 metres from the machine-end plug. At this point there was extensive damage to the outer sheath for approximately 1 metre with signs of penetration to the interior of the cable. The outer sheath was removed revealing damage to the blue phase conductor and its metal screen. However, there was no evidence of arcing or burnt rubber at this point. The damage had apparently been caused by impact with a sharp object.

Further examination and testing revealed no further phase to earth faults. However, I have already indicated that the circuit of this cable was tripped, indicating that it had been energised, and the switches indicated that the miner itself had been powered. The earth leakage in this cable was not the result of a severed power conductor. The lack of arcing cannot remove the inference as to power to the miner at the time of the explosion. Nor is there any indication that the damaged miner cable triggered the explosion.

The shuttle-car cable underwent similar examination. It comprised 3 insulated power conductors laid around a semi-conductive separator which contained a pilot core and 3 semi-conductive insulated earth conductors. The whole was enclosed in textile monofilament tape and around all cores is a heavy duty

insulating sheath. Conductors are each made up of numerous silver plated copper strands. The cable was received in 3 sections.

The anchor section was approximately 1.9 metres long with one end completely severed and having a tear in the outer sheath. It appears that this section was installed in a wedge type cable anchor at the time of the explosion and the tear is adjacent to a corner of the anchor cheek plate.

In the presence of Mr. Lloyd, Director of the Centre, Mr. Muir, Chief Inspector of Coal Mines, two Electrical Inspectors and representatives of cable manufacturing companies, the power conductors were tested for continuity. It was found that the red and yellow phase conductors were continuous, as was the earth conductor between them. All other conductors, including the pilot conductor were open-circuited. The red phase conductor was damaged by a puncture hole through the insulation with copper globules visible and a slight burnt rubber smell. There was no copper dust. This conductor was partially severed. Copper globules were evident on the severed end of some strands. The yellow phase conductor showed a split in the insulation. Removal of the insulation revealed copper globules adjacent to the split. The degree of arcing was obvious.

Although the insulation of the blue phase was severely damaged and the conductor itself completely severed, no evidence of arcing was present. There was no arcing on the severed end of the cable. The earth conductor between the blue and red phases, however, showed signs of arcing, with copper globules adjacent to the damage to the red phase.

The supply side of the anchor showed various places where the outer sheath had been damaged and at times partially removed. There was visual evidence of strand breakage due to impact with a sharp object. However, there was no arcing on any portion of the cable.

An examination of the cable on the shuttle-car side of the anchor, a piece some 93 metres long showed only minor damage to the outer sheath with no penetration to the interior. There was, however, clear corkscrewing of the cable from approximately 20 metres from the plug, indicating considerable stretching and/or twisting.

The shuttle-car cable then appears to have been damaged at its anchor point, being not only severed but suffering conductor-core damage also. It is clear that the damage is the result of the explosion forces, and not the cause of the ignition. Its significance, however, is that arcing had taken place in a damaged section of the cable, indicating beyond doubt that it was energised and therefore that power was on to the shuttle-car when the ignition took place.

It will be recalled that after the explosion the fan cable was found to be in two sections, one length still attached to the fan. These two sections were examined and tested at Londonderry. The longer section, 58.8 metres in length, was attached to a restrained plug, the other end being completely severed. No damage along the cable itself had penetrated the outer sheath into the interior. The severed end showed no evidence of arcing although the strands showed signs of necking. The cable was severed in a manner consistent with external means.

The shorter section was approximately 15 metres in length, and attached to the auxiliary fan by means of a restrained receptacle. The cable itself is made up of 3 power cores screened with semi-conductive rubber laid around a rubber separator containing an extensible pilot core, and 3 earth cores embedded in a semi-conductive rubber filler pad. The conductors are enclosed by a semi-conductive rubber outer screen, taped with nylon monofilament, the whole being covered in an outer sheath. There were numerous places along this cable length where the outer sheath was damaged and partially removed, exploring some conductor strands. The only evidence of arcing was found to be at a distance of 10.45 metres from the fan-end plug. At this point the outer sheath had been removed for approximately 50mm, exposing the blue phase and earth conductors. There were copper globules on the end of one blue phase strand and two earth strands. This indicates the occurrence of a phase to earth fault at the time of damage to the cable. Further examination showed that about 1/3 of the blue phase strands were severed, the ends indicating necking and shearing at an angle consistent with strain on the cable and damage by an external object.

I should say that the matters referred to in the examination of these cables, as well as items and equipment recovered from the mine were demonstrated to me by Messrs. Fisher and Lloyd on a visit to the Londonderry Testing Centre. I am most satisfied as to the detailed examination and testing carried out by these gentlemen at this Centre. They have greatly assisted me and others in coming to correct conclusions.

The significance of the examination of the fan cable should not be lost. It indicates conclusively that power was on to the 'B' heading fan at the time of the explosion. This fact, added to the non-flameproof condition of the fan when discovered, have assumed the utmost importance in my Inquiry. Other items of equipment, machinery and the like were examined underground by Mr. Caulton for faults such as non-flameproof condition. There was no discovery of anything amiss, and these can now be ruled out of the Inquiry.

A major examination of the fan starter, now a prime suspect in the explosion, was undertaken at Londonderry. The starter itself needs some description here. It is a square or slightly rectangular metal box, fitted adjacent to the rear of the fan proper. It has a heavy hinged door, which closes upon a metal flange without any intervening gasket. It is surrounded at its edges by 24 stud or bolt holes. The studs are tightened to blind ends, so that they hold the door to the flange but do not penetrate the chamber itself. A special key is needed to tighten these studs. The box contains transformers and electrical wiring of which only two features are of real importance to the Inquiry. The first is the start-stop circuit which in normal use is operated by two buttons on the outside of the hinged cover. One causes a contact in the starter circuit within, which closes a gap between two points and so starts the fan itself. The other opens the circuit and stops the fan. There is a third reset button which does not concern the issue. Since a spark occurs within the enclosure on the starting or stopping of the fan, it must be flameproofed. This condition is achieved by tightening the cover to 1/20,000 inch. The electrician checks the flameproofing in practice with a 1/10,000 inch feeler gauge. Flameproofing does not mean that the interior of the equipment is impervious to outside flame.

It means that any flame created within the enclosure cannot escape to ignite flammable material, such as methane gas, outside. The flange plays a large part in this, cooling the escaping flame so that it tends to become non-incendive. In actual use a flameproof enclosure may allow gas to enter by a process known as "breathing". The contraction and expansion of metal surfaces through heat may allow its passage or its expulsion.

Schedule VII Regulation 21 of the Coal Mines Regulation Act deals quite explicitly with the opening of a flameproof enclosure when the voltage is switched on in any gassy place. For the purpose of this Schedule any return airway is a gassy place. It should be remembered that all of 3 conditions obtained on this occasion:

(1) the fan was situated in a return airway;
(2) the enclosure (starting box) was not flameproof, being held by one stud only, tightened to two threads;
(3) the power to the fan was on.

Regulation 21 provides that
"in any gassy place a flame-proof enclosure shall not be opened when the voltage is switched on to any conductor or electrical apparatus within the enclosure nor shall the voltage be switched on to such conductor or apparatus while the enclosure remains open."

There is a proviso where special circumstances obtain. If the manager or deputy manager (there was no deputy manager at Appin, and the manager was at home) considers it essential for the purpose of adjustments to electrical apparatus within a flameproof enclosure, that such enclosure be opened while the voltage is switched on or that the voltage is switched on while the enclosure is open, he may authorise the action in writing on a shift on which coal is not being produced and transported by or in the presence of a competent
person (here, the deputy) after a gas test within a radius of 20 metres of the enclosure has shown that less than 1.25% of inflammable methane gas is to be found in the area. The authority is to be recorded in a book.

It is fair to say that in the absence of Mr. Fisher or Mr. Metcalfe, Mr. Oldcorn was in full control of that part of the mine to which he had been assigned, and could have given the necessary authority.

It will be shown that Mr. Oldcorn had only reached the

panel about 15 minutes before. No record of such an authority, of course, exists. There is evidence that the starter cover had probably to be opened at one stage to change the phasing of the wiring. There is evidence that at Londonderry one of the starter contact wires was loose and this may have necessitated the opening of the box. Neither of such operations requires the power to be on to the fan - they are, indeed, best carried out with the power off. It is difficult to conceive of any adjustment or repair which needed power to be on during the adjustment itself. It would be wild speculation on my part to assume that Mr. Oldcorn gave the necessary permission for the fan to be opened while power was on, let alone signed a written authorization for it to be done. Indeed, the methane gas check necessary before the cover could be removed would itself take a substantial portion of the time Mr. Oldcorn was down there, leaving aside the discussion necessary to persuade him that such a dangerous and rare move was necessary. Indeed, if the electrician had already carried out his adjustment and was testing the fan with the cover not closed, the great probability is that this was at least commenced before Oldcorn arrived. If, on the other hand, he was in the act of removing the last bolt, this would already have taken him some time. Of course, if by pressing the starter or stop button he sparked off the explosion, he had already adjusted the fan and it should have been made flameproof again first.

I find myself constrained by the evidence to find that this was a flagrant breach of a safety regulation, which must have occurred with Rawcliffe's knowledge, at least. I can recall no Counsel submitting to me that the action was lawful and properly authorized.

The second feature of the wiring which is of some importance is that which provides for protection against thermal overloads. Stated simply, if the fan motor becomes too hot for one of a number of reasons, for example a build up of coal dust and grease preventing cooling, a device is incorporated which trips the power and stops the fan. At one stage this fan had been approved by the Department with an additional protective device known as "thermistors", which tended to come into play before the normal overload devices. At some time in its history, however, the electrical staff had removed

a transformer which was necessary to lower the voltage for these to work effectively. Some person then rendered the thermistors themselves ineffective. This was contrary to the original approval, but nothing turns on this fact in my Inquiry. However, the remaining protective devices do assume significance, since there is a very strong suggestion that during the explosion shift they were activated to stop the fan, requiring the electrician's intervention and opening of the enclosure.

The starter box was examined carefully by the experts. On each side it has what is known as a "blanking plate". The box is constructed with 2 holes. One takes a cable which leads to the fan motor. The other is for use with a receptacle, in this case usually a stone-dusting device. The instant starter box had no device at the receptacle hole, so that the hole had to be covered. It was covered from the outside by a square metal plate, rendered flameproof by 4 bolts. Incidentally, Mr. K. Fisher noted that the method of drilling all the bolt holes was not approved, in that some entered the chamber and were not welded at the inner end. The inner aspect of this blanking plate shows the hole in the centre, covered by the plate outside.

The exterior and the interior of the starter box was covered by a layer of fine coal dust of a sooty appearance. Mr. Caulton scraped some of this off and collected it for testing by the Chemical Laboratory. It was there described as "sintered coal dust, rounded grains with higher reflectance, possibly coke, noted at high magnification. There were limestone grains mixed with the coal material."

Samples of rope used to tie the wiring and PVC insulation tape were also forwarded to the laboratory. Testing showed that only the rope samples had indications of burning.

Loose rust in the bolt holes of the cover was considered but this was quite consistent with accumulating as a result of standing unprotected before examination. Mr. Fisher noted a number of defects in bolts and bolt holes at the receptacle and motor ends. On removal of the receptacle end blanking plate a feature of apparently great significance was discovered. On the enclosure side of this plate a circular coal-dust

pattern was observed. It was approximately 45 mm. in diameter and showed signs of gas flow radiating outwards. In effect, it gave evidence of a blast pattern inside the starter box.

Various tests were then conducted to show the safety of the enclosure in various configurations. In the first test the receptacle-end blanking plate was replaced with a 6 mm. steel plate having a cable gland entry to allow connection of the main contractor coil to an external power source.

The fan and motor were electrically connected to the starter on existing colour coding. A 415V A.C. supply was connected to the starter. The main cover was retained by a single steel bolt identical to the original in the hole that contained the bolt and tightened to two turns.

The starter was placed in the flameproof test chamber with the cover open against the retaining bolt. The starter-box and the chamber were each filled with a 6% methane/air mixture. This, of course, is near the bottom of the explosion range and was selected mainly for reasons of safety. Power was applied to the starter. Its internal mixture was ignited from a 100V D.C. supply.

The results were as follows:

(a) On starting the fan the mixture in the starter-box ignited and propagated to the external methane gas/air atmosphere.

(b) Apart from smoke there were no clear indications of burning in the starter enclosure. There were indications of burning on the rope and green insulation tape, but not on the black insulation tape. There were unknown red crystals on its adhesive side. (These had also been found on the post-explosion black tape).

(c) A fine coal dust pattern with signs of streaking identical to the post-explosion pattern was seen on the receptacle end blanking plate.

Thus the Testing Centre had reproduced the significant pattern which was seen after the explosion, by a deliberate ignition of methane/air mixture in the non-flameproof enclosure. This was not achieved again when conditons were varied in subsequent tests.

In the second test, the original blanking plate was installed and the cable entry for the contactor coil moved to the other side. The door was closed against its own weight. An amount of coal dust was included in the starter. There was aninternal ignition and an external propagation. The rope showed greater signs of burning and both insulation tapes showed signs of burning. No coal dust blast pattern was observed.

Other tests showed that material such as surgical cotton-wool burned, with differing results, but there was no reproduction of the coal dust pattern. In one test (No. 6) a quantity of coal dust was placed inside the fan starter and the methane/gas mixture external to the starter was ignited. This time a slight coal dust pattern was indicated on the blanking plate but it was not similar to that in Test 1 and had a coarse coal dust appearance. This test was repeated with the blanking plate smeared with a thin layer of grease. A more pronounced coal dust pattern appeared but had the same coarse appearance as in the previous test. A photograph of this type of pattern shows it to be quite different from that produced in Test 1. It does not indicate any methane gas flow and the texture is entirely dissimilar. It is to be noted that these tests were an attempt to show conditions resulting from an ignition initiated outside the starter box, with propagation into the box rather than out of the box.

After the evidence had finished and Counsel were preparing their addresses, a further series of tests was performed on the fan starter box at Londonderry, under the supervision of Mr. K. Fisher. These appear to have been arranged by Mr. Kininmonth, the local Senior Inspector, who for some time had shown that he did not accept the theory of primary ignition within the starter box. He had in evidence not rejected it, but voiced a number of difficulties that he saw and put the methane gasflow pattern down to something which was formed by methane gas being forced into the box as a result of an external ignition. Mr. Kininmonth was accompanied by Inspector Caulton, who appeared to favour the Londonderry theory. Frankly, I fail to see the reason for and the full significance of these tests.

Officially, Londonderry was the originating body for tests and the Department of Mineral Resources made it available to assist my Inquiry. I was faced with the spectacle of the two Southern Inspectors, Mr. Kininmonth and Mr. Mould, initiating or carrying out or encouraging a series of unofficial tests, lending them an air of officialdom by their involvement, while the Departmental experts either conducted their own tests or attended the unofficial tests by request. This dichotomy of investigators allowed every person associated with a test, whatever his background, to be relied upon as a so-called expert by the various parties. I am strongly of the opinion that Departmental tests should be initiated and organised in these inquiries on an officially approved basis by the personnel employed for that purpose. That is not to say that no other party can submit evidence of independent tests and research which will receive due weight. What I stress, however, is the strict distinction of the source of the expert evidence, which is the least that any Court may require, since it has to judge finally what expert evidence it is to accept. I have said that I fail to grasp the reason for some of the tests performed at the heel of the hunt. was it to throw doubt on previous findings of fact by the Centre? If so, why was the Centre asked to take part in them? Two of the tests were conducted with 22 of the cover bolts fitted, and a 9.8% methane/gas mixture. The receptacle and blanking plate showed some striations on a circular dust pattern, the whole plate having been coated with coal dust in one test. In the other small quantities of coal dust were placed in the blanking plate openings. There was a brown sooty deposit on both blanking plates with a definite radiating pattern. In the first test of the series the methane gas/air mixture was allowed to infiltrate the enclosure from the testing chamber and the door was closed against the flange. As in Mr. Fisher's first series of tests with the door in this position no dust pattern was found. In the second test the door was open against the retaining bolt but the receptacle end blanking plate bolts were loose. There was no pattern on the plate, not surprisingly. In the third test the gaseous mixture was ignited externally. No coal dust pattern was found. Mr. Fisher had performed this test with a quantity of

coal dust placed within the starter box and found a slight pattern, quite unlike his original test, made by coarser coal dust. At least the new test showed once again that the blast pattern is not caused by external ignition.

Mr. Fisher says that two of his tests convinced him as to the source of ignition - the first, when the gas-flow pattern was produced, and the last when no pattern was produced after an explosion outside the box. He says of other tests when one might have expected a pattern that in the meantime the blanking plate had been cleaned with solvent, and this might account for the non-adherence of coal dust. He caused no pattern on the motor-end blanking plate, and believes this is because of the disposition of component parts within the box, diverting the methane gas flow from that end.

Mr. M. Lloyd, Director of the Londonderry Testing Centre, a gentleman of great standing in this scientific field and of tremendous experience strongly supports Mr. Fisher's views. He says that the dust pattern is similar to dust patterns he has seen on enclosures which have been tested for their flameproof properties.

The starter box is adjacent to and near the exhaust of the fan. Thus any flame shooting out of the starter box may, under certain conditions make contact with and ignite methane gas coming from the exhaust of the fan. The exhaust leads through the fan to the vent tubing and this would be precisely the kind of path, if the tube contained inflammable quantities of methane gas, which would carry an ignition to the inbye end of 'B' heading stub.

The conditions under which this can occur are, firstly that the fan is emitting inflammable quantities of methane gas - that is, the impeller with its blades must be moving, and the airflow over or at the rear of the fan must be insufficient to clear this methane gas away as it is discharged. The airflow also must be insufficient to prevent gas from entering the starter-box or, if it has already entered and the door is opened, insufficient to prevent its escape.

Why the starter box door was opened is a question to which the answer is vital in determining what happened on the explosion shift. An examination

of the fan itself as distinct from the starter-box provided at least a partial answer. The fan itself is a Richardson centrifugal type down-draft exhaust fan. It resembles in no way the ordinary household fan, whether of the exhaust or of the forcing type. It has no crossed blades across the housing, for example. It comprises an impeller type fan drum attached by bolts to a securing boss. This assembly is fixed to a drive shaft which passes through the fan housing. The impeller turns in a fashion not unlike the circular plate of a rotary lawn mower, but of course, it stands vertically in the housing and is a drum rather than a single plate. Around the edge of the impeller, in the impeller drum, there are fixed vanes or blades, arranged at an angle sloping inwards towards the centre of the impeller. It is these that trap and scoop the air, containing methane gas and coal dust in normal mining use, whence it passes through the housing to the exhaust at the rear of the whole assembly. The exhaust is a cylindrical tube of diameter sufficient to take the ordinary vent-tube. The above is a somewhat simplistic description of the auxiliary fan in 'B' heading. I have dealt, however, with those features relevant to my Inquiry.

Examination of the impeller revealed a fine coal dust pattern on the back. The pattern consisted of a saw-tooth shape. There were also groups of clean areas in the form of apparently straight lines emanating from the centre of the impeller and interrupted by the protrusion of the retaining bolt heads. Photographs show that the lines commence from the hole at the centre of the impeller through which the drive shaft and boss pass, and then radiate outwards. Where the retaining bolt occurs and for a short distance on either side of it, there is a complete interruption to this pattern, so that the lines in fact consist of 6 distinct groups to the outside of 6 bolts. The Testing Centre could give no explanation for the existence of these lines. My own view is that these may result from a detonation in the confined space and I have asked for further tests.

Testing, however, revealed the significance of the saw-tooth pattern. The fan was run in both the forward and reverse direction, that is, in reverse phase. A large quantity of coal dust emanated from the exhaust part in both directions. In reverse rotation the fan

was very inefficient and did not reach synchronisation speed. It was noisy and a substantial leakage of air was expelled from the inspection post. This test was powered by an external 415V supply.

In a second test the actual starter from the 'B' heading fan (Starter 28) was used. When run in reverse direction for approximately 5 minutes it tripped on thermal overload. The fan had been found to draw 110 amps. in reverse as against 48 amps. in forward direction.

The thermal overloads could be re-set by operation of the push buttons on the front panel of the fan starter. Mr. Fisher noted that initial attempts to start the fan from the outside of the starter panel were unsuccessful due to the control circuit wire being disconnected from the hold-in contact. This was the subject of a special test later. The fan was started by depressing the contactor armature with a screwdriver.

For a third test the 'A' heading Richardson fan was used. The difference between the construction of the 2 fans for the purpose of this test were minor and irrelevant. The back of the impeller drum was completely covered by a fine coal dust film. It was operated in a forward direction for 10 minutes. The dust pattern was unchanged. The fan was then operated in the reverse direction until it tripped on thermal overload after about 11 minutes, drawing about 100 amps. at 415V. The film of coal dust began to show a definite cleaning between the fan blades.

The fan was then started in reverse phase again, when it ran for another 11 minutes before tripping out on thermal overload. On this occasion it had produced the same saw-tooth pattern as was found on the impeller of the 'B' heading fan.

A final test on the 'B' heading fan showed that it took 3.1 seconds to reach synchronous speed in forward direction.

The explanation for the saw-tooth pattern was that probably the blades running in the reverse direction pushed air in a different dynamic pattern.

In order to test this theory among others, I asked that Londonderry run the fan in reverse for longer periods. This would assist me to determine, providing the pattern had been formed only during the

explosion shift, how long it could have run in reverse. It was Mr. Fisher's opinion that the dust he saw on the '13' heading fan impeller was "fresh" and contained no stone dust from standing and that it had not formed during previous shifts. As a further check I asked that the fan be run for longer periods in forward phase, to see whether in the ordinary course of running the fan the pattern would have been removed.

These tests showed that the ordinary forward running of the fan over some hours produced no change to the saw-tooth dust pattern already existing.

The fan was then re-assembled and operated in the reverse direction for a period of 10 minutes. The pattern was found to be largely removed, except for areas of the drum which had accidentally become smeared with grease during dismounting and re-assembly. The "mystery" radiating striations were removed with the pattern.

As a final test the impeller drum was cleaned to remove any grease areas and then covered with a fine coal dust layer. It was re-assembled and operated in reverse for 10 minutes. There was no pattern and the dust had largely disappeared.

An important incidental finding on this occasion was that the increase in noise generated by running the fan in reverse was intake air noise emanating largely from the open end of the vent tubes.

The disappearance of the dust which creates the saw-tooth pattern is due to the unusual air flow created by the blades when operating in reverse. One could describe it in homely fashion as "pushing air around corners". The coal dust disappears gradually and the formation of the gaps in the dust is really the removal of portion of the dust. In the end it will all be blown away and the pattern will disappear. On the findings based on the experiments with the 'A' heading fan it would require approximately 20 minutes to generate the pattern. The use of vent-tubes probably shorten this time. The test can not be used as an indication that the 'B' heading fan would behave in the same way. The fans ran at different speeds, the coal dust and its powers of adhesion were probably different and so on. The one matter upon which Mr. Fisher was prepared to be firm was that the fan had been run in

reverse for some time during the explosion shift - enough time to create the distinctive pattern.

Fans and other electrical equipment in mines are prone to be run in reverse phase at some time in their history. There is no real way at Appin for the electrician who couples up the equipment to know in what phase the equipment will run when he receives it, as compared with the power conductors that supply it. There is no uniform electric phasing throughout the mine. Generally this creates little trouble, although there is danger of damage to pumps if they are run in reverse. With a fan, the proper way is to test it by short bursts to determine if it is running in forward phase. If it is found to be in reverse, the starter box must be opened and the operation is easily performed by the exchanging of the position of two wires. It was put to me at the Inquiry that there was a "50-50 chance" of any piece of equipment being in reverse phase when installed. No person of electrical experience dissented from this point of view. There is a method of overcoming the trouble, but it is a matter for the colliery to decide whether to use it. Of course, the changing of the phase must not be performed with the power on to the equipment, if a flameproof enclosure is to be opened. This is not only dangerous to the miners and officials. It is dangerous for the electrician.

If the pattern had been created on a previous shift, there is every chance that it would have been removed. This is not by any means a matter of certainty, but it is more probable than not, in view of the chances of starting the equipment in reverse. It is a matter of certainty, however, that the forward running of the fan would not disturb the pattern. Again, when were the fine-line striations made?

I am not prepared to accept the proposition that the electrician knew that the fan was running in reverse before it tripped out on thermal overload after a period of some 5 or 6 minutes. The final test at Londonderry would show that increase in noise on reverse phase comes mainly from the end of the vent tubes - some substantial distance from the fan. Nor am I prepared to accept that Mr. Brewin, the electrician, tested the fan for reverse phasing by short bursts on the starter button. Indeed, having reviewed the incontrovertible

evidence of complete irregularity in more than one operation on this shift, I an not prepared to accept statements that any official acted as certain witnesses say he would have done, by following proper practices, unless there is something other than the bald opinion of the witness before me. In any case, having accepted the evidence of Mr. Fisher that there was a freshly created saw-tooth pattern on the back of the impeller, I find that the fan most probably ran in reverse for a period of some minutes during that shift.

This in itself would have provided a proper reason for opening the starter box - namely, to correct the phasing. If this was the only time it was opened, then the power should have been off, the box made flameproof again and the power put on again. Of course that did not happen. There is no reason after such a simple operation, within the knowledge of any electrician for the box to be held by only one stud, not even finger tight.

It is for that reason that I look for something else, which may have tempted the electrician, probably with the knowledge of at least one other official to open the box, put the power on - if it had not been turned off - and leave the door in a state where it could easily be opened again. To me the whole picture points to the electrician having effected a repair, perhaps temporarily, and testing it with the option of opening the box again should this repair be ineffective.

There are two possibilities, one a real probability on the evidence, the other specualtion.

The first of these was discovered at Londonderry. There it was found that the fan most often could not be started from the pushbutton on the outside of the starter box door. There was a loose connection to the "hold-in" contact. This was a wire providing a 415V power take off for the control circuit. In other words, the loose wire ususlly prevented power being supplied to start the fan. The fan could be started from within by depressing the contactor armature. This wire was examined. It showed an absence of pronounced flattening of the strands, as if it had not been screwed tight. It also had signs of white oxide, characteristic of arcing. When connected, the testers could start the fan normally from outside. There is some rather

conflicting evidence that the enclosure was clean near this wire, as if somebody had worked in this area. I think I should regard the latter evidence as equivocal, to say the least. However, there was a strong chance that the wire had become loosened during the propulsion and tumbling of the fan by the explosion. I do not think this is completely so, in view of the state of the end of the wire. This must have been at least loose before the explosion.

If this was the reason for opening the box again, the electrician had not completely tightened the wire on his entry. However, this may have been the very reason why he did not bolt up the whole door. He may have placed the wire in definite contact to try it out before he finally put in all studs. If this was so, then there must have been a reason for the fan having stopped in the first place, so that it needed restarting. The reason could have been the thermal overload trip-out. That the fan had been started was shown not only by this evidence. The roll of brattice found in 4 cut-through is also strongly suggestive of the fact. This brattice, as I have said, was approximately of a length to constitute the brattice that stretched from 'B' heading stub across the cut-through to B4. It had been troublesome in actual panel preparation for the changeover, for men and materials had passed through it, as well as the additional vent-tubing to the fan. It had at least one vertical slit, probably two. Schuster was troubled by it and his last action on the shift was his vain attempt to repair it. It obviously left much to be desired in the ventilation of 'B' stub. Without it, however, there would be no real ventilation of the stub either before or after the purported ventilation changeover. Before the change the intake up 'B' heading into the right hand side of the brattice would have had no real negative pressure in 4 cut-through to pull the return air through cut-through into the Longwall 8 maingate return heading. After the changeover, the only intake up 'A' heading would not be drawn up the left hand side of the brattice in 'B' stub to be taken down the new return on the right hand side into 'B' heading.

It would not be taken down by Rawcliffe then unless he had no further need for it. It is logical

to assume that the roll of brattice came from the 'B' stub ventilation. Its most likely place would be at the cut-through. The implication of this is that before its removal the deputy had already instituted some form of fan ventilation in 'B' heading stub. The removal and rolling of brattice is generally the work of the Federation men. A deputy may pull brattice down. He would hardly roll such a wide brattice as long as this himself. It must be remembered that the men were at crib at the time of the explosion. The fan must have therefore been started before they went to crib. The timing of the sequence of events leaves room for guesswork and speculation and therefore does not appeal to me. If the fan tripped out after some 5 or 6 minutes this would barely allow time for the men to remove the brattice, roll it up and go to crib. The electrician would have to be summoned back, assuming He he had started the fan. would open the starter-box He and change the phasing. would then bolt up the door and put the power back onto the fan and start it. is always possible that this last assumption It is incorrect. It could happen that the electrician was not sure that the fan had tripped on thermal overload because of reverse phasing. He might then have decided to test the fan with the door in the condition in which it was later found and so created the spark. This operation would mean that the fan had only been out of action for some minutes. On the other hand, it is possible that another fault developed in the starter-box which the electrician was called on to repair and did so successfully. In such a case there would be no evidence of the fault because the electrician repaired it.

I was beset by this problem and pursue it in an attempt to find the answer. A one time I thought that the answer might lie in the fact that the thermistors had been defeated. This could have indicated that the fan kept tripping out early on overload because the thermistors came into play before the ordinary thermal protectors. It was a dead end. Examination showed that the thermistor circuit simply would not work, in any

This problem still concerns me, but I can find no ready answer. It does not, of course, affect the

case, the necessary transformer having been removed at some time.

main proposition namely that the door of the starter-box either had been opened and temporarily partly closed, or that it was in the process of being opened. Both conditions indicate beyond doubt a fault in the starter box which had to be investigated by the electrician. In either case the fan should have had no power on. The fact that it did, would seem to indicate that it was necessary for the electrician to have the power on to test his work. Of the reasons I have dealt with I find the most probable reason the failure of the push button to start the fan, with the result that the electrician placed the loose wire into contact without fully tightening it.

Although I have presented no situation when it may have occurred, it must always be remembered that the spark created on stopping the fan would also ignite methane gas in the starter-chamber.

By the time these matters had been put before the Inquiry, a school of opponents had begun to form. Although faced with the striking coincidence of a live fan with an open flame-proof enclosure and an ignition pattern within, the members of this school, officials of the Colliery supported to some extent by Inspectors Kininmonth and Mould, and joined later by certain officers of the Rescue Station, began an attack upon the fan-ignition theory and a simultaneous case for suggesting that the ignition had started further inbye because the deputy's safety-lamp, possibly defective, had ignited a body of methane gas/air mixture. I deal with the "lamp theory" in some detail later. First, however, I should discuss the criticisms of the fan theory

Apart from the cross-examination by Counsel, of course, the two Inspectors pointed to difficulties. Both gave a balanced account of possibilities. However, as to the fan, Mr. Kininmonth said that for methane gas to be issuing from the exhaust the fan had to be moving. In that case, the striations on the back of the impeller could not consist of straight lines. Mr. Fisher, without professing to solve the cause of these lines - Mr. Kininmonth gave no real explanation for them either - pointed out that if they were caused by blast, the fan would be moving at a far slower speed than the blast, which could be measured in a speed of milliseconds, and so the lines would appear. straight. Mr. Kininmonth said

that the blast pattern in the fan starter-box - the most persuasive piece of demonstrable evidence - could have been caused as a result of an ignition outside the box - he did not postulate where, but indicated that he meant that it was part of the general explosion, forced into the starter-box itself. No experiment so far has demonstrated this, although the box has been subjected to an external methane gas explosion with the door partly open as when the fan was recovered.

Finally, there was no way in which methane gas could have remained in the starter box or around the exhaust or back of the fan, unless there was some recirculation of discharged air. Otherwise the airflow over the fan must necessarily have carried away the methane gas in the fan box and any methane gas-contaminated discharge.

Both Inspectors joined in this view. They recognised that if the 3 cut-through brattice had not been removed, a situation with effects similar to true recirculation could have occurred, in that air drawn from 'B' stub would not have gone down 3 cut-through into the returns and methane gas could have built up in the heading near the fan and in other places. However, the Inspectors joined in a report compiled and signed by Inspector Mould, which told me (after a series of experiments in a reconstituted 'K' Panel at the mine) that the deputy "had received definite instructions to pull down the brattice in 3 cut-through". (I have found as a fact that he did not, after a thorough judicial consideration of the evidence.) The report goes on to say "the orders given to him were sensible and there is no reason why he should have disobeyed them. It seems likely that he would have carried out these instructions.. These words from independent Inspectors would better come from partisan advocates. However, they do not influence me and I repeat them in order to demonstrate what members of the Inspectorate should not do. What I do accept, however, is the principle, espoused by the opponents of the fan theory, that if for some reason there is insufficient air moving over the fan, methane gas may enter the box and may stay around the fan exhaust. It would then only need a spark to bring about the explosion. These opponents reject the idea that there was insufficient air around the fan.

They also raise a corollary, that the deputy, following the regulations like a good deputy, must have tested for methane gas around the fan. This test would extend to 20 metres (under the Act), and no deputy would start a fan if he found methane gas within that distance.

The last proposition may omit one factor from consideration. Assuming that the deputy had in fact tested for methane gas near the fan, the fact is, of course, that the fan had been started. Taking the benevolent view, one would say that at that time he found no methane gas. However, during the stoppage, with the brattice down, the stub was left unventilated. How much new methane gas built up at the rate I have described, would depent on the time the fan had been stopped. In 10 minutes, as an example, there would have been a considerable build up. This must be added to the pre-existing methane gas which most likely had not been removed on brattice ventilation alone, since it could not be all removed on previous shifts and the brattice was sadly defective when Schuster left it. This does not take into account any deficiency in extraction caused by the fan running in reverse. The real question is whether the deputy made a second methane gas check after the fan stopped, or whether he relied upon his first check, assuming that he made one at all.

Of course, this does not touch the question of whether the deputy removed the 3 cut-through brattice. I have already found on the evidence that he was never told to remove it. He may have discovered it for himself, of course. This would raise the question as to when he discovered it and what he did about it. Under the Act he was not entitled to remove it without instructions from his senior official - in this case, Mr. Oldcorn, since it was an alteration to the existing ventilation system outside his power. However, assuming that he did not make contact with Oldcorn - there is some evidence that he did not - I would assume his tests would in themselves persuade him to remove it because of the danger it could create, without standing upon the niceties of legislation. After all, his subsequent actions showed a disregard for the existing legislation. However, discovery of this brattice in a mine without knowing of its existence is not merely a matter of looking around. There is evidence that he tested for

methane gas in Longwall 8 maingate. Mr. Rawcliffe's initials and the date were found chalked up there afterwards. Any marks of testing in 'B' heading would have been destroyed by the explosion, of course. He had at least 2 hours to spend before the fan could be used, since this was the estimated time for coupling and hanging cables by the electrician. He had arrived at the crib room at about 7.30 pm. It would be about 7.40 pm or 7.45 pm. before he reached the stub headings. There was a difficulty with the Marietta miner which O'Connell had been unable to solve and which he had reported to Rawcliffe, with Rawcliffe telling him not to worry, that he had a capable miner-driver who would look after it. At what stage then did Rawcliffe start his rounds? When, if at all, would he have seen the brattice, realised its implications and removed it?

Rawcliffe was seen in the panel by Mr. N.J. Barnes at about 9.30 pm. or slightly before. He took a flat top loaded with material, as he had been instructed to deliver it to 'K' panel. He drove along the track road, which ended in 'A' heading between 3 and 4 cut-throughs. They were "normal" supplies, a pallet of stone-dust (40 bags) some steels, lagging etc. for production. The men offloaded the material and Rawcliffe was closed to the track-end. He spoke to Rawcliffe, telling him about the delivery. He could not remember what Rawcliffe said, excepting that he was happy about the delivery and said that everything was O.K. His impression was that the men were waiting for the delivery. He had seen him earlier, with an "empty" flat top - that is, one with only a few materials on it. Rawcliffe then told him to take some remaining drums of oil off the flat top and stack them in the rib. He describes Rawcliffe as seeming "very happy and jovial".

Up to this time Mr. Oldcorn was in control, according to the officer-in-charge, Mr. St. Nicolaas. He said that Oldcorn had been there since 7.30 pm, and received no phone calls to his memory. He definitely received no phone call from Rawcliffe. It is interesting to compare the picture presented by this and the previous evidence with what Inspector Mould predicates the deputy would have done. Mr. Mould agrees that even if he had been told of the 3 cut-through brattice he would have been faced with an alarming situation. He does not think

that panic action was required but it was not dangerous if the igniting source, such as power, was kept away from the methane gas.

He says that the deputy would not have allowed all the methane gas to go into the returns immediately, because it might endanger any people working in the returns. Rawcliffe did not phone Oldcorn so he apparently was not too concerned about what Mr. Mould has already called "alarming". The deputy would have begun his ventilation by making first a small hole in the brattice; starting a "ventilation pattern". The next step would be to go to the 'B' stub face and repair the brattice at B4 intersection to drive more methane gas out. The whole operation would have taken between 5 minutes and 1 hour. Mr. Metcalfe does not agree. However, Mr. Mould's deputy tests for methane gas all the time. In the course of continuous methane gas testing he would be including Longwall 8 maingate, clambering backwards and forwards through the overcast several times. 'B' heading would be included in his checks. He would then put a brattice over the fan in 4 cut-through, controlling the flow in the maingate and driving more air into 'B' heading. Finally on tearing down the 3 cut-through brattice, he would allow the position of stabilize, leaving some methane gas in 'B' stub, layered at the inbye end. I have given this evidence some detail in description, though not as fully as I might, in order to test this hypothetical deputy by comparing him with the Mr. Rawcliffe found waiting at the track end and receiving materials less than 115 hours after his arrival in the area, apparently in good spirits and "jovial".

It could be said that he must have noticed a peculiar situation as to airflow. But Mr. O'Connell after the ventilation had been changed - noticed nothing different. Rawcliffe would have felt the new full intake flow in 'A' heading and the flow from there to the maingate via 4 cut-through. He may well have noticed intake leakage in 'B' heading and through that this was something that Schuster had mentioned and decided to look at it later. His main problem would be methane gas in 'B° heading stub, but O'Connell's report had already referred to this.

According to Mr. Fisher, the Manager, he had received an instruction from Mr. Oldcorn about stone-dusting before he went on shift, and this obviously was on his mind. Oldcorn had his instruction from Mr. Metcalfe in writing. It was most insistent that the 2 miner headings and 4 cut-through be stonedusted before all else. Oldcorn had made a written note of this and was carrying it on his person when found. It is difficult to account for his conduct. He appears to have spent some 2 hours in control, but made and received no phone calls. He then went about his ordinary rounds - South West headings and 'A' panel, before arriving in 'K' panel. In fact he was seen apparently on the way to 'K' panel, at about 10.30 pm. He could not have arrived there before 10.40 pm. - possibly as late as 10.45 pm. The explosion occurred 15 to 20 minutes after his arrival. There is no sign of alarm or haste in his conduct at all. There is nothing to show that he believed there was any cause for concern in 'K' panel. His behaviour, indeed, points to the reverse being true. Again, if he obeyed Mr. Metcalfe's instruction his main concern also would be to see the stone dusting done, prior to any production.

In fact there is no sign that the stone-dusting machine was ever used, or that any stone-dusting had taken place. The shuttle-car power was on, and since the shuttle-car can be used for the transporting of dust, its use in the near future may have been contemplated. However, power to the miner was also on. It is hard to contemplate what Rawcliffe must have done by way of testing for methane gas in 'B' stub when one realises the implication of methane gas building up. The estimate is that if it mixed, a $9^1/_2\%$ mixture of 50 cu. ft. of methane gas/air would be made in $3^1/_2$ minutes of an unventilated stub. The miner was allowed to stand at the entrance to the stub with power on, and its live cable was looped for a substantial distance inbye. It is difficult to attribute any action which Rawcliffe must necessarily have taken in view of these facts and the condition of the fan when discovered.

One could follow Mr. Mould's hypothesis and come to the conclusion that he made all safe from methane gas. If so, then how does one account for the large methane gas build up? Or, if this built up while the

fan broke down, how did he miss it and allow power onto a cable so far inbye the stub? One alternative is to say that he did not follow the ideal course of behaviour, but as soon as he could get the fan working he used it to remove a large body of methane gas from the stub. He did not get very far before the fan stopped. His brattice was at least partly down and rather than re-instate it, he ordered urgent repair to the fan, his his sole source of ventilation.

This, of course, does not answer the questions as to whether the 3 cut-through brattice had been taken down. However, in view of his unorthodox behaviour as we know it, it is impossible to say that he must have taken it down, though that statement may be unpalatable to many and has been rejected by the two Inspectors. It is conceded by all that in these circumstances, not only the starter-box could contain methane in explosive proportions, but also the vent-tubes and the atmosphere around the fan itself. Thus it could explain why a spark in the starter-box triggered the explosion. On the other hand, there are alternative explanations for this event. If I accepted the fact that the origin of the explosion was in the starter-box and that there was no other explanation for it but that the 3 cut-through brattice still remained, I should be compelled by logic to conclude that the immediate cause was that Rawcliffe failed to remove the brattice. As it is, I do not make that finding, but merely leave it as a still possible cause.

The second possibility is a failure of the 'B' heading brattice outbye 3 cut-through. This had an initial weakness in that Schuster found it stapled to the inbye side of the props (corroborated by Prinz and Dyson, who erected it) and therefore it was incorrectly erected, since air-pressure behind it could help to dislodge it in time. The management with the aid of the two Inspectors attempted to re-constitute 'K' Panel as it was described by the evidence describing its state at the commencement of the new shift. This was done late January, 1980. On 31st January and 1st February, some 6 months after the explosion tests were conducted by Mr. A. Fisher, Mr. Metcalfe, the Senior Research Engineer from A.I.S. Rock Mechanics Department and the two Inspectors. Mr. Mould prepared the report

on this venture, and I have already referred to some of his comments, drawn from this document. The report comments, inter alia, on the fact that the brattice in 'B' heading showed no sign of coming away from the props after 2 days. The report in many ways is of value. However certain imponderables which it assumes to be true, lessen the weight of some of the observations and resultant conclusions to be drawn. At this stage I refer only to the 'B' heading brattice, which appears to be of no concern to the experimenters, although during the evidence it surprised Mr. Fisher who apparently had only heard of the mistake in stapling at the Inquiry. It certainly concerned Schuster, who contemplated taking it down and consoled himself with the thought that it would "do for starters". What is imponderable is the quality of the job performed by two workmen who were doubling up on shift and wanted to make sure that they finished in time. As it was, according to them, the completion took them until 7.00 pm. or after. Of course, they said that it was a good, tight brattice - one would not expect them to say otherwise. However, it had to withstand the pressure of intake air to that point in 'B' heading, forcing it through 2 cut-through into 'A' heading. On the assumption that the 3 cut-through brattice was down - and that is the assumption I now make - 3 cut-through was a return, just inbye the brattice, pulling on the brattice with some force due to the negative pressure now created. One cannot assume that this brattice necessarily stayed in place because a similar brattice, erected under managerial and inspectorial supervision, also stayed in place.

Be that as it may, the experimentors tried pulling this brattice away from the props in steps, measuring the results. Before removing the brattice the leakage through it was 2.6m^3/sec. The brattice was loosened to the first prop on one side, but still attached to the roof (as if a man had passed through it without proper replacement). The leakage increased to 11.37m^3/sec. and the 'B' heading air flowed outbye to 3 cut-through at a rate of 11.49m^3/sec. The brattice was then pulled down further to produce a gap of about 30% of the cross-sectional area. The leakage increased to 2.74m^3/sec. and the flow in 'B' heading inbye 3 cut-through reduced to 7.84m^3/sec. when both

fans operated with "spoilers". I do not intend to go into the physics of "spoilers". Briefly, an instruction has been issued at Appin that auxiliary fans should have spoilers behind them. These may vary in their nature. For example, a spoiler may consist of a piece of brattice held firmly or a piece of leather belting - which in fact was used behind the 'A' heading fan and fell down at times. The theory is that the velocity/pressure of the exhausting air from the fan may be so high as to cause re-circulation. It is not known whether 'B' heading fan was run with a spoiler - it should have been. The experimenters found that with a spoiler the flow in 'B' heading increased to 11.49m^3/sec. They note that with the earlier higher leakage the air flow past the fan was barely discernible - it was on the point of recirculation. The question of spoiler or no-spoiler on the 'B' heading fan becomes largely academic, of course, if the fan is stopped for repairs. Unfortunately, I can find no test with a substantial part of 'B' heading brattice down and the fan stopped.

However, the experiment went further. When the brattice was pulled down exposing about 60% of its area to intake air both fans had to be stopped to avoid re-circulation and the brattices at A4 and B4 intersections were restored. The leakage had been increase to 29.23m^3/sec. and the flow in 'B' heading (still outbye) decreased to 4.70m^3/sec.

One observation is worth special attention. Despite this leakage 17m^3/sec. of air still reached **4** cut-through 12.5m^3/sec. passing down the Longwall 8 maingate. The importance of this fact is that a deputy in the cut-through, could not realise that the ventilation system had broken down. It must be remembered that the 'B' heading brattice was some 100 metres from the 4 cut-through and not visible by cap lamp or oil safety lamp from there. If a workman who did not realise the importance of the brattice, or the electrician himself, not expected to be familiar with ventilation practice, in a hurry, wanted to get into 'B' heading, his only other access was via 4 cut-through. Alternatively, if he wished to reach 4 cut-through itself, he had either to go via 'A' heading or the maingate - the former would not be difficult. But the brattice in **'B'** heading was new to this shift, and

short-cuts in mines are used by workmen. I have dealt already with what frequently happens to brattice in this way.

A further matter should be borne in mind. Assuming that the brattice had already been deliberately loosened to a minor degree, the remainder of the fastening must surely be weakened under pressure. The fact that the brattice during the test did not come down is then somewhat irrelevant.

Finally, on the test the brattice was pulled down entirely. It only affected air quantities marginally. However, it was observed that the air in 'B' heading stub became stagnant about 25 metres inbye B4 intersection. There is little doubt, then, that even if the 3 cut-through brattice were removed by Rawcliffe, a failure, deliberate or otherwise, of the 'B' heading brattice could have caused methane gas to collect in the fan-starter box, by re-circulation of what was being exhausted at the time, and gone unnoticed. It is quite possible in these circumstances that the deputy tested for methane gas at the fan, prior to it being started, and that the brattice failed soon after, allowing the dangerous condition to develop. With a substantial but partial failure of the brattice, one would assume that the fan was operating or there would have been no recirculation. A gradually worsening defect would cause methane gas to collect at the fan, particularly if the tubes were removing high concentrations of methane gas, even layers. On the other hand, it is just as likely that the electrician safely ran the fan in a non-flameproof condition, until recirculation began, and then stopped the fan, to place all the studs in, or to tighten the loose wire or for some other reason. The resultant spark would have been sufficient to ignite the methane gas in the starter box.

At this stage I refer to what I believe became another "area of concern" to the management after the Inquiry was announced. It covered the issue of air quantities in 'B' heading available at the time 2 fans were running in 'K' panel. It is a truism in auxiliary ventilation that there is'a minimum requirement in regard to the amount of air which must be available to an exhaust fan for it to perform effectively. If this quantity is not present, there is a grave danger of

recirculation of the exhaust gases. These minimum requirements vary with the make of fan, and even 2 fans, apparently identical, may show different quantities necessary for proper functioning. A formula has been devised which should be followed meticulously, even though it may appear rather too generous as to the air it gives the fan. The formula is always based upon the quantity which the fan draws "in open circuit", that is, without vent-tubing, which tends to lower the available air necessary. Upon the figure thus obtained there is added 30% of the figure, this apparently to meet ventilation drops and the like. Every mining official knows the formula. Yet it will be noted that Mr. Mould on a chance visit found the fan operating with only just enough air and a condition of recirculation barely avoided.

Air quantities can be measured with 2 instruments, an anemometer or a velometer. At Appin, deputies and indeed, assistant undermanagers, were not supplied with either instrument in the ordinary course of work, although doubtless these would be made available on request. Mr. B. Jerome among other duties had the task of reading air quantities monthly and on request, at various parts of the mine. He kept rough notes in a book, which included his calculations. He entered the final readings in a special book kept at the mine, referred to as "Monthly Ventilation Reports". His readings were taken on the "split" in the return heading for the panel, even though the form called for "Quantity Air in Split Intake". He also measured quantities within 100 yards of the face. His readings were usually taken early in the month.

According to the maker, the Richardson fan draws 16,000 cu. ft./min. This figure appears to low. Mr. Fisher considered that 18,500 was the actual figure, although he had received correspondence quoting 18,300 and 18,600 cu. ft./min. Near the end of his evidence he was shown a document which he acknowledged was a test graph produced by his Company, and which showed that on test the true figure was 19,800 cu. ft./min. Air quantities in panels are liable to changes up or down, according to what is being done outside the panel. An obvious example is an outbye rockfall which blocks off intake air, or if in a return, creates great

resistance to the return flow, lessening air available to the panel. However, there are many other factors which can affect the supply. A mere reading of the quantities available each month in the air ventilation reports confirms this. The record at the split for 'K' panel itself reads: February 19.67, March 18.23, April 19.76, May 20.50, June 11.57, July 24.91. There There is another figure for July, which I shall deal with. A marginally sufficient figure for the available air is a possible source of danger and shows that the colliery is prepared to take risks. On the figures for the Richardson fan believed to be correct by Mr. Fisher, 48,100 cu. ft./min was a bare minimum for both fans. On the new capacity, 19,800 cu. ft./min., 51,480 cu. ft./ min was essential for 2 fans.

Here it is necessary to convert metric figures of cubic metres per second into Imperial figures of cubic feet per minute, or vice versa. I shall deal with approximate conversions only. The first figure for July of 24.91 m^3/sec. converts approximately to 51,000 cu. ft./ min This was obviously a marginal figure for either the earlier fan capacity or the later true capacity revealed. At the face the figure was 16.70m^3/sec. - far too low. It must be remembered that, apart from any drop in quantity, any substantial uneven splitting of the air available as between the 2 fans could readily starve one fan of air. Regulation would not only be essential, but critical.

The evidence called on behalf of the colliery amounted to a knowledge of the problem and a method of dealing with it. In effect, the colliery had two ventilation problems on hand at the one time. It had to keep undertakings about ventilating the Longwall returns and it had to provide sufficient air for the new development in 'K' panel. It really used the one measure to solve both problems. It commenced the sealing off of 'E' panel. Thus it made more air available for use in the mine. It lowered resistance in the 'K' panel returns by creating parallel airways and cutting the number of stoppings from 10 to 3. There is no need here to deal with the intricacies of the ventilation methods planned by Mr. Metcalfe. They were amply demonstrated at the Inquiry and showed considerable skill and ingenuity. I believe it is true that the main

beneficiary was the Longwall Return System. At the same time, 'K' panel gained some air, enough in the ordinary comtemplation of the planners to work the system, provided all preparation was sound.

I have referred to this as "an area of concern" for the officials. Mr. Jerome measured the air quantity specially on the 23rd July - at Mr. Metcalfe's request it had risen to 26000m^3/sec. (converting to approximately (54,700 cu. ft./min. 'E' panel had not been completely dealt with. By the next day he expected more. Mr. Metcalfe tells of Mr. Jerome's reading. However, Mr. McAlpine and Mr. Walsh say there were 57,000 or 58,000 cu. ft./min. before the changeover. Thus in fact was what Mr. Metcalfe says he hoped to get by 24th July, but he never knew, because no measurement was taken.

Mr. McAlpine, in fact, says that he was given this as a result of Mr. Jerome's reading on the same day.

Mr. Jerome's figure was entered in the book in somewhat strange fashion, giving rise to suspicion. However, there is a third set of figures, taken in the week before the explosion, which are not entered at all in the official record book, but appear in his notebook. It showed air in 'B' heading 7.92m^3/sec. (about 16,774 cu. ft./min. air in 'A' heading 9.66m^3/sec. (about 19,127 cu. ft./min.) 'K' panel split 21.8m^3/sec. (about 46,170 cu. ft./min.) showing a fall here from the earlier reading of about 3m^3/sec. This reading was taken in Red Panel return, which is 'K' panel return. The reading noted in the record book (26m^3/sec.) is not taken there; it is taken on the return side of the 'A' heading fan in Longwall 8 maingate between 3 and 4 cut-throughs. The witness says it is "virtually an intake reading". He entered it in the Report book as air in the "split intake" - in other words, taken where he had taken previous split return readings. The entry is, of course, incorrect in its description. The witness says he had to keep the figure over to the left to leave room for what he wanted to write, so that it appears in the wrong column. What he wrote reads: " N.B . 'K' Panel 26.00 ventilation change due to the sealing off of 'E' panel. This measurement taken on 23-7-79". He had made the entry after the explosion, and in fact says: "Had the explosion not occurred I would not have put that reading in". He says he was not instructed to put it in but

thought it would be relevant perhaps later on as the last possible air reading. However, if this were the only reason, it would not be necessary to refer to the cause being the sealing off of 'E' panel. Mr. Jerome wished to add credibility to the increased figure by pointing to this.

When one realises that the figure purports to be a reading with 100 yards of the face, it is a great increase on any figure in that area in 'K' panel before. The earlier notation for that area in July read 16.70m^3/sec. and so the new figure is over 9; /sec. more. Mr. Metcalfe had contersigned the record before Mr. Jerome put the new notation in the book.

When I visited the mine on 25th July, I ordered that all records be impounded, so that the Court would be sure that there was no loss of or tampering with documents relevant to the explosion. The order was heard by a number of officials, with the result that records, including the relevant record book, were taken by the Secretary and retained by him. It is fair to say that Mr. Metcalfe was not present, since he was underground and involved in rescue work. I find it difficult to believe, however, that he did not become aware of the situation, since access to records must be part of his duty. It transpired that this book was removed from security so that Mr. Loy, Check Inspector, could read the figures it contained. The contention put forward is that the book was not made secure again, but allowed to lie by itself on a safe in the Secretary's office. Whether this is true or not, I cannot say, but I am prepared to accept the account with the comment that I find it difficult to understand such contempt of the Court's order. No explanation for it and no regret has been expressed to the Court by any person on behalf of the colliery, and I pause to wonder at the general attitude which allows such conduct.

Be that as it may, it is irrelevant to the issue of how Jerome came to enter his new figures in these circumstances. His first evidence to me was that he took the book from the usual pigeon hole in a desk in Mr. Metcalfe's office without Mr. Metcalfe knowing and then made the late entry, some short time after the explosion. When it was made clear to him in re-examination that the book was supposed to be locked

away he changed his evidence, claiming a faulty recollection, and stated that he went searching for the book and happened to find it lying on the safe in the Secretary's office. He made his entry without permission and told Mr. Metcalfe afterwards. The Undermanager expressed his satisfaction at his action. There is no evidence of any query by Mr. Metcalfe as to either how he acquired the book, (which, after all, was missing from Mr. Metcalfe's office) or what motive he may have had for his action.

I have set out this account, because I feel that the evidence of McAlpine and Walsh, exaggerating the reading taken by Jerome, and the eagerness of Jerome, to be able to display a written record, not only of the reading, but, most surprisingly in a record book consisting of figures, the means by which the management had achieved the reading, indicate that the officials were concerned to defend themselves against any allegation that might be made that they had attempted to run 2 fans with insufficient air. By this time, of course, the fan in its non-flameproof condition had been found and it was a prime suspect in the ignition. It must also have been obvious that ventilation was involved.

In the end Mr. Metcalfe was put to detailed proof of the work done in 'E' Panel to bring about the result for which he was aiming rather than offering (as some other officials had done) the bald statement that it was achieved by the "closing of 'E' Panel". In fact, he put the picture offered by other officials straight. I accept this account and the figure read by Mr. Jerome of 26m^3/sec. or 55,000 cu. ft./min. It was expected that the figure would rise to something like 58,000 cu. ft./ min. by the final work done on the panel before the changeover the next day. I am doubtful of the optimism displayed by Mr. Fisher that a figure of 60,000 cu. ft. /min. plus was "feasible" because of the simple reason that there was no evidence that such a figure was ever achievedd. In September Mr. Fisher said that at the time there was 60,000 cu. ft./min. in the panel, but "under a different ventilation set-up". The late January, 1980 tests were performed with a total air quantity of 32m^3/sec., but I do not take that statement to mean that this was probably the quantity available at the

time of the explosion. There was now a large cavity in the roof, "particularly in Longwall 8 maingate" considered irrelevant because it was outbye. With some hesitation I accept this statement. There was, however, a large cavity above the rebuilt overcast at A , which cavity above the rebuilt overcast at A3, which was relevant. A brattice sheet was erected above it to attempt to simulate the pre-explosion aperture. The air quantity was reduced to 27/28m^3/sec. (57,000/ 59,300 cu. ft./min.) to simulate the air which the experimentconsidered was available. This quantity, in view of my finding, is fair enough - however, in view of what Mr. Metcalfe hoped to achieve by the ventilation changeover time, it is in fact a little generous. I make no complaint about this. This should have been sufficient to run 2 fans, but, according to Mr. Metcalfe, he did not expect the air to split evenly so that the same quantity would be available to each - the Maingate side would be favoured and therefore the air would have to be regulated. In fact, the experimenters found variations between these quantities which did not starve either fan. Indeed, with both fans running and spoilers removed on each in one test, 'B' heading received more air than Longwall 8 maingate, a somewhat surprising result.

Of course, air quantities may drop as a result of a happening outbye. Anything blocking the airflow in the intake, or a short circuiting of the air by holing through an essential stopping outbye will cause a loss in airflow which may be substantial and remain unnoticed in the panel inbye. Again, obstruction to the return airway or any event increasing the resistance in the return will bring about a similar result. These are unknowns. There was in fact a fall in Longwall 8 Maingate - it had left the cavity in the roof - but it appears to have been established that this occurred as a result of the explosion and is thus irrelevant. The same can be said about the destroyed overcast. However, we do not know by evidence the state of stoppings outbye. We know that a number of stoppings (for example 5 in White Panel belt road) had been affected by blast 'K' Panel. There is no evidence now as to whether any stopping had been damaged before the explosion, so as to cause ventilation to drop. I mention this as a

possibility, although on 23rd July in the morning there was ample air available for the changeover.

I should state for the record that Mr. Metcalfe agrees that he did not know of Jerome's entry in the air heading book. In fact, he indicates that he disapproved of the unauthorized action and says that when Jerome told him what he had done it was too late to do anything about it. He also disagrees with Mr. McAlpine's and Mr. Walsh's version of the figure established at the reading.

One matter which still concerns me is the use of brattice for the stopping in 'B' heading. Mr. Metcalfe's notepad - in which he left messages for his assistant undermanagers, was produced to the Inquiry. His message for 23rd July - directed partly to Oldcorn, in relation to 'K' Panel reads: "3. Day shift will finish o'cast and B Hdg. stopping (Plaster board required to deliver for this stopping) IE: 10 metres inbye of B2". This, of course, was written after Jerome's morning air reading on 23rd July, so that at that stage Mr. Metcalfe could have expected the ventilation changeover on that day. If so, his expectations were not realised, because the overcast was not completed until the late afternoon of the next day. His note for 24th refers to "Plaster board in panel". I have already described part of his instructions to Oldcorn concerning stonedusting. The note goes on (it was written between 2.00-3.00 pm.): "See Vic regards ventilation changeover". If Walsh's evidence is to be accepted, he telephoned Walsh at about 6.45-6.50 pm. when Walsh had not heard about the 3 cut-through brattice. The note then reads: "Work both these units if possible. Stop S/West if necessary".

Oldcorn had written a reply to a query on the note, indicating he had read it. Mr. Metcalfe, after denying that his note re-stonedusting showed a sense of urgency, agreed that he wished the changeover to be effected as quickly as possible, and that he wanted both the miners to be working on that shift. Yet he denies that there was any plan to use plaster-board to effect the changeover. The plaster-board was not mentioned in the planning notes of 18th July. A plan of the stages of the changeover, prepared for the Inquiry, indicates a brattice stopping, but in the final stage this is

removed and a plaster-board stopping is substituted further outbye, in conformity with a description "inbye of 2 cut-through". The plan submitted for fan approval to Mr. Mould, strangely enough, shows only the brattice stopping. The plan produced by the Mines Rescue Station, which could only have come from the colliery information, despite strong assertions that it was only produced for internal use by the Station itself, shows a plaster-board stopping in place where the brattice was erected, followed by a question-mark.

Mr. Metcalfe says that the erection of plaster-board, though available and delivered early for the purpose, would have taken longer to erect, even though more satisfactory than brattice. It would be erected later, as a permanent stopping, brattice serving the temporary purpose. According to Schuster, he had to tell the men where to find the materials for the stopping. I cannot escape the belief that brattice was substituted for plaster-board because the changeover was running behind schedule. In the event, it does not matter, because, as Mr. Metcalfe agrees, the intention was to effect the changeover swiftly. It is to be noted that no assistant-undermanager was present at its completion and what evidence there is of the effectiveness of brattice and overcast comes from Schuster and the men.

Schuster says he noticed a considerable leakage by way of "reverse air-flow". He claimed that brattice stoppings leak by 20%. According to Mr. Metcalfe there is no general rule. The experimenters in January of this year attempted to simulate the conditions of 24th July. They had only the evidence offered by the workmen at the Inquiry, and they apparently accepted this at face value. To this extent the figures as to leakages are unconvincing to me. I would discount this evidence substantially. In the first place, no man is going to give evidence that his own work is unsound, particularly after a disaster such as this one. Secondly, Schuster himself showed great concern for what he found - enough to make him "shut up shop" and start all over again. Mr. Metcalfe says that the combined leakage from a good tight brattice and a well constructed overcast would be something like 3-5000 cu. ft./min.

However, there are indications, apart from the concern of Schuster, that the leakage was greater than that. Mr. J. Christ, who supervised the building of the overcast, described it as "one of the best in the pit because there was no bad separation, there was no guttering in the rib". He conceded, however, that he would not be able to check for leakage until it was in operation, with screens pulled down and fans blowing. He would come back to remedy leaks. As far as he was concerned he had finished it quickly, to get production going. He noticed air leaking from 'A' heading towards the maingate - an impossibility if there was a tight brattice in 3 cut-through between the overcast and the maingate.

The conditions of the overcast became the subject for lively discussion again on the calling of Mr. R. B. Webb, a machineman who had worked on the overcast. Webb gave his evidence late in November, well after Christ and Schuster had finished the evidence relating to the subject. In fact, a statement was taken from him for the first time by Inspector Rose on 27th September. What goes on behind the scenes as far as witnesses are concerned is a matter about which the Court tends to learn nothing and it is dangerous for a Judge to guess. However, when Webb told the Inquiry something that Christ had not - that there were bricks missing from the top of the overcast, the gaps that were left being stuffed with crumpled brattice wedged in with wood, I was concerned that this evidence had come to light so late in the Inquiry. Mr. Murray, who led the evidence, made the picture more disquieting when he informed me that he had only received the document a few days before. The statements providing the proofs of evidence for Mr. Murray originated either from police officers or the Inspectorate. This was a document which had been made late and which had not reached Counsel assisting me until 2 months after it had been made. I expressed my concern, not for the first time during the Inquiry. No explanation was forthcoming.

The evidence was of great importance. It tended to explain the reverse flow of air from 3 cut-through which Schuster had noticed. It obviously affected the whole question of ventilation in the panel, and in turn affected the question as to whether there could be methane gas around the fan, despite the air readings.

What Webb said was that the overcast walls were built of concrete blocks or bricks, 10 inches by either 6 or 8 inches. There were spaces between the top of the brick work and the roof. On the left hand wall on the outbye end there was a space of probably 2 to 4 inches, 3 to 4 feet in length. This was stuffed with brattice. On the opposite wall on the right hand side at the inbye end there was the depth of one brick missing, extending for about 4 feet. At one point the depth was 2 bricks for a distance of about 20 inches. That also was stuffed with brattice. Although there were bricks available to fill the gaps, Christ told him to fill the gaps with brattice. His reason for not using bricks, apart from this, was that he was there to concrete the roof - he said they stayed a shift to do this and the understanding was that when they finished the concreting of the roof, they had finished their work and they went. At all times he was working in 'A' heading under the overcast.

Christ was then recalled on this fresh evidence. He confirmed the evidence of Webb as to the holes and his instructions to put brattice in them. He said that he told Webb, "When I come back tomorrow I'll seal it off". He added that you can't tell where the holes are or seal the overcast when it is not in operation. He referred to a brattice in Longwall 7 tailgate ('B' heading) that leaked and was only temporary, and his overcast was like that brattice. Schuster, recalled, said he had not noticed the holes. Schuster in a statement to the police tendered in evidence had said there was considerable airflow from 'A' to 'B' headings in this cut-through, despite the brattice plugging in the overcast. He knew it had to come either from the overcast or the brattice beyond it in 3 cut-through. His evidence was not that of a man who was dealing with the ordinary leakage which might be expected. I have come to the conclusion that when Mr. Metcalfe estimates the combined leakage from brattice and overcast as no more than 3-5000 cu. ft./min. he is contemplating an ordinary, effective overcast and tight, well-constructed brattice. In fact, he gave his evidence before Webb and could not have known the facts. I cannot escape the feeling that both jobs were hurried so that the men could finish them and leave the panel. Of

course, at the explosion shift, the overcast had not been sealed. We are not told the state of the overcast in the January experiment.

It is quite possible that double the leakage estimated by Mr. Metcalfe was coming from both brattice and overcast. This was intake air in 'A' heading. It was leaking close to the return airway. A 10,000 cu. ft./min. leakage would go via 3 cut-through into the maingate return if the cut-through brattice were removed. The total intake air would be reduced by it. Despite the figure of $5^{7}/_{5}8000$ cu. ft./min. estimated as being available, this figure would be dangerously reduced. An uneven splitting of this air between the two fans could well have starved the 'B' heading fan and recirculation could take place, with the consequence that an explosive methane/air mixture would exist around the fan itself. For those who must remain sceptical towards this possibility I should offer this reminder. In the January experiment the leak was only "a drift". There is no evidence whatsoever of the air quantities which would remain in 'B' heading after the 3 cut-through brattice was removed. If there is no other source of ignition excepting the fan, for which there does exist evidence, methane gas must have been allowed to collect near the fan starter-box. One then has to look for possible sources of accumulation. There is no doubt that if Schuster is to be accepted about anything, it is his description of his great concern over the strong reverse flow of air in and about 3 cut-through before the 3 cut-through brattice was removed. It cannot be an error or invention. This concern cannot be explained in terms of customary leakage, with which any deputy must be familiar. I should add one other feature which gives me some concern - the activities of some people at the colliery concerning what was said by witnesses at the Inquiry. An example of this is that Christ said that after he first gave evidence a deputy accused him of being "a company man", that he had tried to hide things and speak in favour of the company, by not revealing that there were "large holes" in his overcast. He explained to the Court that he had not lied, that the holes had been filled with brattice. One cannot help speculating, however, why a finding that the overcast leaked to an unusual_ extent would be adverse

to the colliery if it did not partly explain the explosion.

The exposition of the theory that the ignition was commenced by the deputy's oil flame safety lamp is in itself interesting in this Inquiry, although I judge the theory itself on its own merits, objectively. It arose out of a desire by its exponents to avoid the fan starter-box as the ignition source, by the raising of a credible alternative source. So one Counsel explored the possibility of live cables as a source of ignition, postulating, for example, that the fan cable had been used before and was therefore old. Unfortunately, any cause had to be near enough to an accumulation of methane gas to ignite it. For a time the Auer methanometer, carried by Mr. Oldcorn, became a probable source, if only because the testing of it did not seem sufficiently exhaustive because of its damaged state. The deputy's safety lamp was also damaged to the extent that it could not really be tested, and of course, became a suspect source of ignition. Of course, if the methanometer or the lamp could be shown to be possible ignition sources, it made a more comfortable result from the management's point of view and that of others - true it was that the Act had been breached in opening a flame-proof enclosure while the fan was "live", but it was irrelevant to the explosion itself, which was caused by an unsuspecting official doing his duty in testing for methane gas. The methane gas of course, still had to be explained but all would have been safe if there was no ignition point. The gas would have been removed in the ordinary course of ventilation, in any case.

Rawcliffe's body had been found in the shuttle-car. This was immediately seized upon as a possible explanation which fitted "the lamp theory". He had been testing for methane gas at the roof and his lamp apparently somehow came into contact with an explosive mixture. There were immediate difficulties which awaited an answer. Firstly, why was he testing outbye 'B' stub - for that was the location of the shuttle-car? Secondly, how did methane gas in that proportion come to be outside the stub? If it was there, possibly it was near the fan. Thirdly, why would an experienced deputy put his lamp near the roof, where he might expect to find methane gas? Would he not use his Garforth bulb

in the ordinary manner to collect methane gas and then insert it into his lamp in an obviously safe place?

The position of Rawcliffe changed. One of the rescue men, who had found his body, described it as wedged between layers of cable. It appeared to him, he said, as if the upper layers had been blown vertically at the same time as Rawcliffe had been blown into the shuttle-car - with his lamp, apparently, for it was there also, although it was separated from him. Then the cable coils had fallen back upon him.

This, of course, was a theory, which might explain the position of the body. It has its own difficulties and is by no means a certain account of what happened to the unfortunate deputy. It was immediately accepted by the lamp advocates, particularly when it was suggested that Rawcliffe may have been standing on the boom of the miner before he was forced into the shuttle-car. What could he have been doing on the miner boom? This could well have been a place to look for methane gas - at the roof above the miner. Again there was the difficulty of explaining how he could have tested at the roof with his lamp. It was then discovered that the lamp wick was not lowered, as in the methane gas-testing position, but raised in the carrying position. He was no longer testing for methane gas, he was breaking the vent-tubes by himself and somehow his lamp, which he could not be holding at the same time, came accidentally in contact with explosive methane gas from the vent-tubes at belt-level. To quote Mr. Mould again - he had worked on the distances-

> "If the deputy was standing on the continuous miner breaking a pair of vent tubes because he had found gas in the tubes and his lamp was hanging on the left hand side of his belt (a normal position) gas spilling out of the tubes could have enveloped the lamp. It should be borne in mind that the height of the miner is about 4 feet and the flame of his lamp would have been about 2 feet 6 inches above this, i.e., over 6 feet from the floor. This is approximately level with the bottom of the vent tubes".

There is a certain difficulty about this picture. Methane gas does not "spill out" of vent-tubes - it tends to rise. However, it may be that the tubes were broken close to the lamp. If the lamp were not

defective, the flame would rise and be extinguished in the lamp. Again, if it were not defective, it would not ignite a body of methane gas. That is the fundmental safety factor of Davy's oil flame safety lamp - that it can be carried into a body of methane gas without igniting that gas. I deal with the evidence as to possible defects in this report. The reason why the lamp does not ignite inflammable methane gas is because covering the only possible exits for flame in a non-defective lamp are 2 gauzes which do not allow the passage of flame. It must be remembered that this type of lamp has been carried for many years in gassy mines, because it is safe in a similar sense to a flame-proof enclosure. The reason why it is not plunged into known concentrations of methane gas is that it is extinguished. Modern lamps may be of the re-lighting type. Former lamps were not - a miner-driver's lamp is still not a re-lighting type at Appin. It must be taken to the surface to be relit and is sealed to prevent its being opened. Rawcliffe's lamp could be relit by a special key which caused friction on flints in the relighting mechanism. Even that relighting is performed in a place known to be free of methane gas, a "safe place" under the Act, so that a frictional spark will not ignite methane gas.

Of course this argument does not touch the procedure of breaking vent-tubes. I have already described these tubes - 30 inches in diameter, as being joined and sealed at the joins by rubber seals. Frequently a wedge is used to part this join. The action can be performed by one man with difficulty - the size of the tube itself makes the necessity of a second man obvious. The reason for breaking the tubes is that it is an incorrect procedure to allow concentrations of inflammable gas which can be found on a locked oil flame safety lamp, (that is of a concentration of 1.25% or more) to pass within 20 metres of an electrically driven fan. That has already been referred to as a regulation under the 7th Schedule of the Act. All conscientious officials fear the passing of a "plug" of methane - that is, something like a layer - through the vent ducting. Apart from the Act, it is dangerous for such a plug to be allowed into the return airways, when men may be working. The correct procedure of the deputy to prevent

such a situation arising, is to break the connection of the vent-tubes at a point outbye of where he has found methane gas in the heading. In that way he draws pure air through and the methane gas gradually follows it, diluted with air. A layer which may enter is broken up by the air and mixed with it - once mixed it does not layer again. The deputy then breaks the tube further inbye when he has ridded the general body of methane gas and reconnects his original break. At times, if methane gas is found further outbye in the heading, he may have to disconnect the vents at the fan until he attains a pure air condition.

The account of Rawcliffe breaking the vent-tubes leaves open the question as to why the tubes had not been broken earlier, when the fan was first started. If they contained the explosive mixture necessary to be ignited by the fan, where had Rawcliffe tested in the tubes themselves, if that was the reason suggested by Mr. Mould? In an unbroken line, there are only two places where one can test - the end near the face, or the exhaust of the fan itself. Assuming that either of these places contained an inflammable mixture, why had not the lamp caused an ignition then? Really, the question in the long run, whether the lamp was the ignition source or the fan starter-box via the fan exhaust, was why had the deputy allowed the vent-tubes to become filled with methane gas? If, indeed the flame in the starter-box had ingnited the methane gas in the exhaust, as a result of a spark in the box, the vent-tubes were still drawing a heavy concentration of methane gas/air, and had not been properly broken. In fact, since the main explosion was created by flame from the tubes reaching the inbye end and the methane gas accumulation in that area, the tubes extended to that area and were not broken at all. Experiments by the Associate Professor of Metallurgy at the University of N.S.W., Professor Hatherly, revealed that almost all the vent ducting was not damaged by internal explosion, but by external explosion. The single exception, he said, could have occurred in the later stages of the explosion.

Only a limited examination of Rawcliffe's lamp could be made because of its damaged condition. But it raised the general question of defective safety lamps

and their possible part in methane gas explosions. The lamp itself was sent to the Department Chemical Laboratory at Lidcombe, where a counterpart of Mr. Ellis, Mr. A. P. Mackenzie-Wood, Senior Scientific Officer of the Gas Chemistry Section joined the investigation. He specifically set out to examine the conditions under which an oil flame safety lamp could ignite an external flammable methane-air atmosphere. He enlisted the aid of experts and in particular he received the practical help and advice of the Southern Mines Rescue Station. Most laboratory tests were conducted in the Station's gas chamber.

The gauzes in the deputy's lamp, obviously damaged, were sent to Associate Professor Hatherly for examination. Various bodies co-operated in tests and information. The C.S.I.R.O. at North Ryde conducted a survey and search of world literature on the subject, using the Compendex Computer. In all there has been probably the widest and most intensive investigation of the oil flame safety lamp generally and the lamp as used in N.S.W. mines that has ever been conducted in this country. Mr. Mackenzie-Wood, with the results of his work and the contribution made by others, has produced a voluminous and detailed report which adds substantially to mining literature in Australia. Whatever inference I draw as to any part played by the deputy's safety lamp in the Appin disaster, the Inquiry has brought to light by this means a most valuable piece of research for future use.

I shall not attempt to elaborate the detailed findings of this Report, except insofar as any finding is relevant to my Inquiry or to recommendations which I make for the future as a result of my findings.

The only safety lamp used by the N.S.W. Coal Mining Industry is the Protector, made in the United Kingdom by Protector Lamp & Lighting Co. Ltd. and marketed in this country by Gilbert Gray & Co. Pty. Ltd. There are a number of models of this lamp. Rawcliffe's lamp was a G.R 6 S(A) - that is a Garforth relighter type, with a stainless steel wick tube and a lead rivet seal. This lamp must be fitted with gauzes of 28 mesh.

The Superintendent of the Rescue Station (Mr. Strang) asked miners to write reporting whether they had witnessed flame passing through the gauzes of lamps. He received 3 claimed incidents, 2 of which were

anonymous, but coming from persons known to Mr. Strang. These statements, being uncorroborated, cannot impress me greatly. There was no stated cause for the incident in any case.

world reports of ignitions from flame safety lamps are surprisingly few. Mr. Mackenzie-Wood obtained 3 German reports, 2 British reports, 8 ignition in a U.S. Bureau publication and 2 ignitions in Belgium.

The 3 German reports were as follows:

1. An extinguished lamp opened and an attempt to relight it (1948).
2. A faulty safety lamp when a miner attempted to test a hanging layer of methane (1959).
3. A miner tried to relight the lamp and the glass cylinder shifted, so that the ignition spark of the lamp ignited methane directly (1963).

The lamp is implicated in 2 British explosions. In the first (1952) there was no defect in the lamp but a particle of pyropnor, ground oft by the relidhter mecnanism was ignited.

in the second the lamp was disassembled because the relignter was not working and it was taken by mistake to a gassy area to be repaired, and after being struck, the spark ignited tne methane gas.

The United States Bureau of Mines implicated the safety lamp 8 times in 364 explosions. 5 of these involved a defective safety lamp. One was described as either "smoking or flame safety lamp". One ignited a pocket of metnanc' gas in tne roof, details not given and the otner was a case of the lamp being held in front of a compressed air nose.

Tne 2 Belgian ignitions, both in 1965, were suspected of having been initated by flame safety lamps wnich had been placed close to a compressed air operated injector, used to clear an accumulation of methane.

It will thus be seen that ignitions thought to have been caused by the flame safety lamp were either due to a detective lamp, or to a lamp used improperly, or being used in any case in conditions which were irrelevant to the Appin ignition.

In Great Britain over 6,000 oil flame safety lamps remain in service, although it has been criticized. It still is the best instrument in ordinary use for testing for lack of oxygen. In Europe the use of the lamp is restricted, because of inaccuracy, not because it is unsafe. In Germany it is used to measure oxygen deficiency, but not in methane or wherever hydrogen is present.

A Protector lamp of the same type as the deputy's lamp was subjected to a number of tests, with botn a carrying flame and a test flame by raising it into methane layers and various concentrations of methane mixed with air. Tne lamp was also inclined at an angle of 45^0 impacted against chamber walls, dropped suddenly to tne floor of the test chamber, preheated with an extended test flame and tested also by igniting fuel-air mixtures inside the lamp.

The experiments were repeated with Appin coal dust and pyrophor flint particles sprinkled over the gauzes. Various metnane percentages were fed into the lamp by tne Garforth injection inlet and the effect was noted.

Various components of the lamp were omitted in the assembly, and faulty components were fitted before raising the lamp into a flammable atmosphere. The experiments were repeated using an SLA lamp in a flammable methane/air mixture and remotely igniting the mixture inside tne lamp.

The lamp was raised into a flammable methane/air mixture and the glass was broken. In another experiment water was sprinkled on an overheated glass.

The lamp was raised into a flammable methane/air mixture witn the relignter key missing and the lamp base screws loose.

A lamp witn 2 pyrophor flints in the relighter mechanism was relit in a flammable mixture by inserting and withdrawing the relighter key.

A lamp with holes in both gauzes was tested by raising the lamp into a flammable methane/air mixture and remotely lighting the mixture inside the lamp. The same lamp was lit and raised into flammable methane/air mixtures.

Various tests were conducted on lamps fitted with defective gauzes.

The results of these tests show that in almost all tests no propagation of flame to ignite a methane layer or external flammable methane/air mixture occurred. A typical effect was a small explosion inside the lamp, which extinguished the flame and caused burning inside the gauzes for varying periods.

In one test a powdered pyrophor bar, sprinkled over the gauzes, sparkled when the particles met the flame. when pyrophor particles, sprinkled on top of the outer gauze, were raised into a layer of methane, they glowed red. All attempts to ignite external flammable methane atmosphere failed.

When the glass lens was broken in a flammable methane/air mixture the flame was extinguished. However, when this test was conducted in fresh air, the carrying flame remained alight. If, however, the lamp could be kept from moving wnen the glass was broken in a methane/air mixture it ignited the external atmosphere. A lamp with carrying flame, already holed, when raised suddenly into a flammable methane/air mixture, ignited it.

It was found that more effort is required to relight a lamp containing 2 pyrophor flints than a lamp with a single flint. Withdrawing the key produces a more intense spark than inserting it. Withdrawing tne key results in a greater build up of pyrophor dust.

If holes of 1/16th inch diameter were in both gauzes, directly in line with each other, and a flammable methane/air mixture inside the lamp was ignited, flame passed through the holes and ignited an external flammable mixture. Holes separated concentrically allowed no propagation of flame.

Lamps were examined from 26 southern collieries, including Appin. A number in service had defective gauzes, with small holes or broken gauze wire, discovered under an illuminated magnifying glass. One lamp, fitted with 2 defective gauzes from Appin, was placed in a flammable methane/air mixture, caused the mixture to be ignited by an ignition inside the lamp. Other defects found included defective washers, dirty sinter discs, loose bases, loose and bent pillars, worn wick tube adjustment, cracked solder on bases and locking devices, chips in glass lenses and brush bristles in gauzes. Of 741 lamps examined, 151 were found to have

defects. 119 defective gauzes were removed from service. Some of the lamps had manufacturing defects. Apart from numerous defects in gauzes on manufacture, 66 lamp glasses at 11 collieries failed to meet the specification of tolerances; some were too short, some defective in wall thickness and 5 cut of parallel. Some had defective sintered rings and the retaining wall was defective in a number.

However, apart from the lamp fitted with defective gauzes in juxtaposition, it appears that only one lamp ignited an external methane gas/air mixture by propagation from inside. The base of Rawcliffe's lamp was assembled with parts of good condition, but a glass from South Bulli was added, whose ends were out of parallel by 3.5 mm., so that it left a gap over the asbestos washer. A 9% methane/air mixture ignited inside propagated to a similar mixture outside.

Rawcliffe's lamp (G55) had a number of defects after the explosion. Its glass lens and asbestos washer were missing. The bonnet and gauzes were flattened. Three base screws and the Garforth port assembly nut were loose. It had a missing relighter key. Three support parts were loosely screwed into the base plate with the fourth sheared off. The base plate was apparently defective. The gauzes were apparently defective. The carrying handle was partially straightened. It was noticed also that the steel wick tube fitted loosely in the tube seat and was short of the bottom of the brass base plate. The glass plate was worn on one side.

The most important defect, however, which became apparent under the illuminated magnifying glass, revealed 3 small holes in the outer gauze, similar to corrosion holes; the inner gauze showed severe corrosion. The gauzes were separated and tendered in evidence. With my consent they were sent to the University of N.S.W., where Professor Hatherly examined them. His report shows that the inner gauze was severely corroded prior to the explosion and large holes in the side walls of this gauze must have been present prior to the explosion. However, the outer gauze showed no evidence of deleterious corrosion. What appeared to be holes caused by corrosion were really a number of fractures of wire-strands caused by being struck by

debris during the explosion. No flame, therefore, could have penetrated the gauzes to propagate ignition in the external methane gas/air atmosphere. A possibility would have been the existence of pyrophor particles in the gauzes which might glow, causing external ignition. Even tneir existence would be no certain indication of an external ignition. However, there was no positive confirmation of cerium, present as a result of the existence of pyrophor, but there was "some indications of its presence". There is no statement that this was found in the gauzes. The sample was not big enough for more through analysis.

Tests on broken gauzes to show at what temperature a flame may pass through corroded gauzes were inconclusive "since some badly corroded gauzes performed as well as new gauzes".

C.B. Platt, in a report entitled "The Testing of Flame Safety Lamps", dealing with the tests necessary to be performed on safety lamps in Great Britain to secure statutory approval of their use under the Coal Mines Act, 1911, points out that:

> "While a lamp may be safe under laboratory tests, its continued safety will depend on a high standard of maintenance in the colliery lamproom".

Mr. Mackenzie-Wood says that one should be concerned at tne local standard of lamp maintenance; in the southern coalfields alone the investigation detected 151 defective lamps in service. There should also be concern as to the quality control of lamp components, particularly gauzes, glasses and base plates.

Professor Hatherly criticizes the type of wire used in gauze manufacture - there is "no metallurgical justification for this strict limitation to iron or steel", which oxidise to form magnetite scales. There are now available many metallic materials in wire form which will not oxidize or corrode in collieries. I am pleased to report that Mr. Mackenzie-Wood is now investigating, with the concurrence of the Department of Mineral Resources, the availability of alternative materials for gauzes and the general improvement of standards for components of safety lamps. The Australian agents for the marketing of the lamp have demonstrated their willingness to remedy faults in standards and to endeavour to provide components which will meet the conditions demanded by the Department and collieries.

Mr. Lloyd had described the lamp as having a "large safety factor". Testing had confirmed this, because despite the many defects discovered in the lamps, it was very difficult to obtain propagation of methane/ air mixture outside the lamp by ignition from within. Even where the ends of the glass were out of parallel, leaving a gap at the glass plate, propagation only took place by forcing the internal flame on relighting the lamp.

In answer to a question in cross-examination Mr. Mackenzie-Wood said that Rawcliffe's oil safety lamp could not be responsibly excluded as a potential source of ignition. However, he agreed that he had not taken into account any other factor in the actual explosion, for example the evidence as to where the ignition itself may have taken place. It is obvious that suspect lamps in explosions cannot be investigated as a probable cause without investigating at the same time all other evidence as to the explosion. As an example, one must ask how the lamp came in contact with methane gas in the vent-tubes and why, assuming it had been used for testing substantial quantities of methane gas previously on the shift, its defects had not then become apparent. Of course, one cannot leave out the evidence as to the fan. It is useless, therefore, to speculate as to whether the glass may have been broken in some way at the same time as the deputy had broken the tubes and had raised nis lamp suddenly through methane gas. In the same way it is useless to suggest that in some way a vent-tube filled with methane gas caused the lamp hanging on the deputy's belt to explode, without demonstrating that the lamp contained such a defect as would cause it to propagate a flame externally. Such speculation is not evidence which a Judge can consider in order to base a positive finding of fact.

In the final result the evidence of Mr. J. R. Barnes, lamp room attendant at Appin Colliery, put an end to such speculation. He has had 14 years' experience in this work and bears a reputation second to none in the southern coalfields. His evidence justified his reputation and was most convincing. He explained and demonstrated the methodical way in which he serviced all lamps in the pit, including the gauzes, which he brushes. The lamp is cleaned and inspected

every day. The system makes sure that no component part is left out of any lamp. He uses a soft brush supplied by the agents for cleaning the lamp. He countered the suggestion in evidence that brushing serves no useful purpose by saying that from experience, if one does not brush a lamp, one must get dust all through the gauze. He agrees that during brushing the lampman cannot ordinarily note corrosion._ It is obvious that Appin moisture or atmosphere may corrode gauzes more quickly than they become corroded at other mines. However, now that Mr. Barnes had been supplied with an illuminated magnifying lens (a "Maggy lamp"), he has been able to detect defects in gauzes that were not visible to the naked eye.

As to defective seating of glass in a lamp, Mr. Barnes says that lamps are always tested by blowing - there is an asbestos washer to take up slackness in fitting, but his lamps are always tightened and sealed. He has never had a glass with a hole in it, but he has had 5 glasses cracked through high flames in 14 years. The blowing test around the lamp, says Mr. Barnes, will find out if it is tight enough. The deputy has to check his own lamp before he goes underground.

Mr. Barnes serviced Mr. Rawcliffe's lamp before he took it underground. He was satisfied that the lamp was in good condition. Mr Rawcliffe would have taken his lamp below already lit. It had been properly cleaned and tightend.

What emerges from the investigation of safety lamps in the southern coalfields is the necessity to improve standards of maintenance generally. The most important requirement is that the lampman should pay attention to gauzes. For this it is essential that the lampman snould be supplies with and use an illuminated magnifying glass, since the beginning of wear and corrosion in the wire mesh usually cannot be detected by the naked eye of even the most experienced lampman. It may be that other materials for gauzes will soon become available and that such new gauzes can, in sufficient supply, replace the old. Another aspect of the use of the lamp to which attention should be paid is the necessity for proper standards in the supply of parts. Defective parts should be discarded. Inspections by Departmental Inspectors from time to time of lamp

construction standards and maintenence would do much to eliminate the hazards of the past in the use of the lamp in mines.

It is now obvious that I cannot accept as any form of probability the proposition that the deputy's safety lamp caused the first ignition. Nevertheless, a number of Counsel, representing varied interests, urged upon me that I should return what is often called in Coroners' Courts "an open verdict". They acknowledged the speculative nature of any finding "in favour of the lamp". At the same time they adopted the argument put forward in the report on the January mine experiment that the fan switch chamber was an "obvious source of ignition combined with an unlikely explosive mixture". In other words, they said that it was possible to say that the fan was the source of the ignition but it was impossible to say how the methane gas entered the starter-box or stayed around the back of the fan, and so the fan as the culprit was also only speculative. This, of course, was an invitation to say that I had failed to find, after a long and exhaustive Inquiry, what

triggered the explosion took 14 lives.

tha The argument put piece forward is a fallacy and a

of sophistry which I reject. Having removed the lamp from suspicion, largely by the very failure of numerous tests to propagate an ignition through known defective lamps combined with a completely unconvincing set of circumstances as a hypothetical setting for the lamp to ignite the methane gas, there remains only one possible culprit - the fan starter-box. In the box there were discovered definite, objective signs that an ignition took place. The signs were reproduced on test. Further testing revealed that they were not reproduced by an external explosion. True it was that some things remained unexplained. For example, the striations on the back of the impeller, interrupting the saw-tooth pattern lacked a laboratory explanation. I had referred to vibration due to detonation in the fan-housing as a possible cause. I had no expert opinion to back my view.

A further matter for great conjecture was that the fan, weighting almost a ton, had been moved some 25 metres down the heading, when some bodies had not moved far, although other, more solid, objects appeared

to have been moved further. When I noted this evidence in Court, I expressed my surprise, and my words received some publicity in the local Wollongong newspaper. The Soutnern Mines Rescue Station decided to experiment to try to explain this phenomenon. A model gallery was built with objects simulating the miner, shuttle-car and tan. The latter was attached to a tube, simulating the 'B' heading vent-tubing. Methane gas was introduced into the chamber, to an explosive percentage and ignited in various positions. Videotape recordings were made of the results and I viewed them by invitation.

The results were spectacular. The experimenters had used clear plastic to simulate the vent-tubing. Through this it was possible to see vividly the transmission of flame from the various points of ignition. I do not attempt to describe all the tests. However, one was regarded as most important. In all others, particularly where the methane gas in the tube was ignited at the outlet end (simulating ignition at the fan exhaust) the "fan" did not move, despite the subsequent inbye explosion of methane gas. When ignition took place at a pre-determined position in the tube inbye of the fan, the fan was blown violently out of the test chamber. I was assured that it would happen every time. The inference, of course, is that in the 'B' heading explosion the fan moved a distance of 25 metres because the vent-tube methane gas was lit along the inbye length by the deputy's lamp.

Mr. Ellis, wno had been invited to watch the actual experiment, had another possible explanation for this result. I shall not trouble to expound theory and counter-theory in view of what has since ensued. It must be remembered that the gentlemen of the Rescue Station had attempted to make their model with the machines (miner, shuttle-car and fan) conform to actual conditions. This they had failed to do. They explained that their testing was "qualitative" rather than "quantitative". Indeed, when the fan felt its most violent snock, the "miner" was moved and the "shuttle-car" turned turtle. It is apposite here to quote Ur. H. Titman's words in his report on "The Use of Models in the Investigation of Underground Methane Explosions (1959)":

> "The scaling laws applicable to the many factors that could affect the propagation of flame in models were not precisely known. Geometrical scaling presents little difficulty but it is found to be impossible to reconcile all the aerodynamic factors in a model".

'Pitman than goes on to discuss the factors upon which a roof layer depends, in terms of velocity of airstream and buoyancy. As I understand it, matters such as these were not taken into account in the model constructed, and I can see no relationship in scaling between the simulated fan in the model and the actual fan in 'B' heading.

Be that as it may, however, I am grateful to the gentlemen of the 'Rescue Station for their interest, enthusiasm and perspicacity. I had already urged further testing, for which an explosion gallery had to be built at Londonderry, and this had been promised. The construction fo the gallery itself, no minor task since it had to withstand substantial explosions, was in the hands of the Department of Public Works. Its completion, no doubt for very proper reasons, was delayed and it became a race against time for the testing to be done until this Report could be reasonably completed. In fact, I had completed my observations on the 'B' heading fan, as they appear above and had commenced preliminary work on the deputy's safety lamp, when I received news that certrain tests had been performed and as well certain additional information by way of expert opinion was available. It has come to me in Report form. I deal with the expert opinion first. I set tnese matters out in fact as a kind of addendum to what I nave already written.

Mr. L. Griffiths, one of my assessors, with Mr. M.R. Lloyd and Mr. K. Fisher of the Londonderry Centre, went to Melbourne and visited the Aeronautical Research Laboratory and the Materials Research Laboratory of the Department of Defence and the works of D. Richardson & Sons, fan manufacturer. The experts at the Aeronautical Research Laboratory were Dr. K. Fraser and Dr. S. Fisher, of the Mechanical Engineering Division, Dr. A. Kepert, of the Vulnerability of Aircraft Division, Dr. J. Warren of the Combustion Engineering Division and Mr. D. Edwards of the Instrumentation Division. Dr. Warren is a Combustion Engineer with considerable experience in the behaviour of explosive

gases. He stated that each gas has a certain minimum deflagration speed, which for methane is approximately 2 metres a second; corresponding to a thermic reaction. This speed will increase as successive pressure waves are set up and reflected, which causes deflagration to develop into detonation.

Detonation is a more violent phenomenon than deflagration in which the flame speed is the same as the speed of the pressure wave and exceeds the speed of sound. There are certain factors required for detonation such as the length of gas and the richness of the mixture. The point of ignition also affects the violence of the explosion, the greatest violence in a tunnel being caused by ignition from the closed end.

He expressed the view that the 'B' heading arrangement represented a classical detonation situation, and in view of the amount of disturbance in 'B' heading, detonation in fact had occurred. This was based on the effect of gas alone. Involvement of coal dust in the explosion could have produced the effect of detonation from deflagration of the methane/air mixture. Dr. Warren also said that the post-explosion damage pointed to the fact that the initial point of ignition was somewhere near the mouth of 'B' heading and that this could have propagated to 'B' heading through the ventilation tubes. The effect would have worsened after ignition in the heading itself due to compression of unexploded methane gas at the closed end.

Botn Dr. Warren and Dr. Kepert (who is responsible for the reconstruction of aircraft after missile attacks) considered that movement of the fan had occurred as a result of pressure from outside rather than from the ignition of methane gas inside the fan. Neither officer had seen any pattern like the radial lines on the back of the impeller. They offered the following explanations:

1. The effect of the shock wave of air flow leaking through the gap between the motor shaft and the fan housing. However, tney would have expected a similar pattern on the fan housing at the back of the impeller. Londonderry had not found one.

2. The effect of water of oil radiating from the motor shaft while the fan was running. Tests at Londonderry show that if this happens a non-symmetrical pattern is formed, unlike the regular radial pattern.
3. The effect of vibration or stress set up in the impeller due to shock waves. This was considered the most likely explanation.

It was agreed that the sawtooth pattern on the back of the impeller could in all likelihood be caused by the fan running in reverse.

The group also considered the injuries to persons involved in the ignition. Opinion is that a pressure wave travelling down the heading has its maximum effect in the centre of the roadway and least effect at the floor, sides and roof. The pressure at these parts would be vertical to the surface and would tend to force objects into the strata rather than drag them along the surface. The extent of the injuries sustained by Brewin and Oldcorn indicate that it is likely they were killed by the initial ignition and due to being prostrate on the floor were not greatly affected by the pressure wave from the main ignition. (I add that Rawcliffe's position in the shuttle-car may well be explained by his being thrust upwards from wherever he *was* standing, as were the upper coils of the cable in the shuttle-car.

As to the pattern on the fan starter blanking plate it was generally agreed that this appeared to be caused by dust and possible soot from an internal ignition.

At the Materials Research Laboratory, the Sydney experts met Drs. Eadie, Oliver and Theo. The Laboratory is actively involved in research relating to explosions and their effect. They are mainly involved with solids but have extensive experience in the explosion of fuel/air mixtures in the air. It was their opinion that it is not always possible to differentiate between a detonation or a fast deflagration of a gas/air mixture.

Dr. Eadie was also of the view that a methane gas combustion inside the fan would not move it any distance. They agreed with the likelihood of an ignition of methane gas in the stub as a result of flame

propagating along the ducting with the initial ignition occurring at the tan. An additional factor relating to the degree of Rawcliffe's injuries was the reduction of the roadway section at his location due to the presence of the continuous miner and the shuttle-car.

Possible explanations for the radial lines on the impeller cneck were:

(1) the effect of mechanical factors such as vibration or shock in the impeller drum;

(2) the effect of air flow along the motor shaft due to horizontal movement of the fan.

D. Richardson & Sons, fan makers said that the 'B' heading fan was manufactured in 1972. It was agreed that the sawtooth pattern was the result of turbulence when the fan was run in the reverse direction. The tan makers also expressed the view that the radial lines were due to a diaphragm effect set up on the impeller by a snock wave - that is, due to vibration. They also confirmed that when a fan is operated in reverse it delivers much less air - approximately 60% less.

The report describes preliminary tests in the new explosion gallery at Londonderry. As Dr. Warren had said, a detonation or high speed deflagration can occur in a gallery 50 metres long. The speed of travel was shown on test to depend on a number of factors, including the point of ignition, the ratio of methane/air in the atmosphere and the length of roadway. The maximum speed apparently requires a mixture above 7% methane air. It also depends on ignition at the closed end.

A test involving a 7.2% mixture was ignited near the open end of the tunnel and video recorded. There was a slow deflagration, the flame front requiring approximately 18 seconds to travel the full length of the gallery, giving a speed of approximately 2.7 metres a second. Tests with initiation near the closed end produced nigh flame speed and pressure of up to 121(Pa. The fan moved a distance of 2 metres.

Thus the movement of the fan must have been caused lay a high speed deflagration with some coal dust involvement.

The testers conclude that coal dust had some influence in increasing the energy available. A new conclusion introduced is that the position of the bodies

seems to indicate that the initial ignition occurred at the fan and travelled up the fan ducting, igniting the mixture at the closed end. Apart from other conclusions already dealt with by Londonderry they say "although the radial line pattern has not been finally resolved the most likely explanation is that it was caused by vibration as a result of the blast impact".

Further tests at the Explosion Gallery were programmed. Results are contained in Mr. Fisher's report of 15th April.

In Test 1 the 'B' heading fan, fully assembled, had a layer of coal dust applied to the back of the impeller and blanking plates and placed centrally at the open end of the gallery. There were no vent-tubes. At 15 metres from the closed end a plastic screen was erected, segregating this end. 7.5% methane gas/air mixture was introduced - measuring 86m^3.
Prior to ignition the methane gas concentration was measured at 7.8%. It was ignited 1 metre from the closed end.

Brown smoke was emitted from the open end and as the shock wave emanated from this end, a low intensity sonic boom was heard. It was accompanied by an orange flame. The fan was moved 2 metres towards the open end at an angle. The impeller was forced along the shaft towards the housing and was observed to rotate for a short period.

There was no coal dust pattern on the back of the impeller or the blanking plates.

In Test 2 the fully assembled fan with coal dust on the impeller and blanking plate was placed at a distance of 7.5 metres from the closed end. It was enclosed by a plastic screen located 15 metres from the closed end. A nominal 7.5% methane gas/air mixture was introduced into the intake of the fan. No methane gas/air mixture was introduced into the area of the flameproof starter, but was allowed to diffuse inside by leaving the door open. Pressure transducers were installed at different distances from the closed end.

The methane gas/air mixture internal to the fan was ignited by means of a spark plug located adjacent to the main contractor.

Ignition of the internal methane gas ignited the external atmosphere. The fan did not move. The

back of the impeller showed no radial lines. The receptacle end blanking plate revealed a circular dust pattern having slight signs of striations towards the outer edge. It had the same appearance as the original pattern on the fan blanking plate but was not as fully developed.

Maximum static pressure was generated at the open end of the gallery. Indications were that the speed of flame propagation was approximately 160 metres/second.

In Test 3 Test 2 was repeated with the methane gas/air mixture ignited on top of the motor shaft at the back of the fan housing. The results were similar to Test 2 althougn the static pressure was slightly less. However, there were no dust patterns on the back of the impeller or on the blanking plate.

In Test 4 no fan was used. The gallery was sealed at the open end and the entire gallery fitted with a 7.5% methane gas/air mixture. A video camera was installed. The ignition of the methane gas vapour at the open end showed a slow combustion towards the closed end. Only heat vapour emanated from the open end. The flame front took approximately 18 seconds to reach the closed end and flame propagation time was approximately 2.7 metres/second.

Test 5 gave spectacular results. The fan was placed at the open end of the gallery, with coal dust sprinkled on the back of the impeller and some coal dust to the interior of the fan starter. The fan was located within a plastic bag in order to retain a small quantity of methane gas about the fan. A length of 30 inch tubing (identical to Appin vent-tube) was attached to the fan, its open end 10.5 metres from the end of the gallery.

At the closed end was a 30 metre length of methane gas/air mixture. Pressure transducers and a video camera were installed.

A 7.5% nominal natural methane gas/air mixture was introduced to the gallery and allowed to circulate about the fan tnrough a 6 inch diameter plastic pipe. The flameproof starter door was left open.

The concentrations of methane gas prior to ignition were roughtly the same - about 8%. The mixture internal to the flameproof starter was ignited.

The result was ignition of the atmosphere about the tan and propagation of flame along the ventilation tubing. The flame required approximately 1.75 seconds to travel the 36 metres of tubing, that is, the speed was approximately 20 metres/second. Prior to the flame issuing from the open end of the tubing reflection of light from the interior gave a halo effect. On issuing the main methane gas/air mixture ignited rapidly with an explosion resulting in installed equipment being dislodged. Pressure indications showed that the flame propagation speed was in excess of 600 metres/second. Dense brown smoke issued from the open end of the gallery

The fan was moved a distance of 45 metres from the open end and was severely damaged. Part of this damage came from collision with the side of the gallery.

The vent-tube adaptor and air flow cone were dislodged from the fan housing and travelled about 40 metres. The impeller and retaining key were dislodged from the housing and found about 20 metres from the fan. The fan nad turned through an angle of 180^0 and landed on its base prior to rolling on its side, as in Appin. The flameproof starter was dislodged and travelled about 80 metres. Contact with the ground broke up the starter and its components.

There were no coal dust patterns on the back of the impeller and blanking plates. The interior of the starter-box otherwise had the appearance of the box after the test Mr. Fisher had first performed at Londonderry prior to the building of the gallery.

The vent ducting was severely damaged and uncoiled, but not to the same extent as at Appin. should point out that at Appin some pressure would have diffused down 4 cut-through. Again the effect of pressures in the smooth-sided gallery would differ from the same pressures in Appin's rough-sided 'B' stub.

These tests do nothing but confirm what I have already found. It is obvious that it is not possible on every occasion to achieve the same tell-tale dust pattern on the blanking plate. Many factors must be involved, such as the ability of the exploded methane gas to escape from the box and the presence of the coal dust in the right place. Nobody has yet ventured an opinion of precisely why it occurs, although it is agreed by those who support the theory that it is the result

of methane gas igniting fiercely in the starter-box. As a layman, I dare to rush in where angels fear to tread, as I have already in putting forward my explanation for the striations on the impeller plate whicn has not been rejected, as I see it. The blanking plate covers a hole, which remains as a slight circular well in the centre, viewed internally in the starter-box. I feel it requires a small pocket of methane gas in this hole to ignite at the right time. The resultant small blast imprints its pattern on the surface of the plate which surrounds it. It cannot be reproduced by an explosion from without, whether it be by flame front or shock-wave. The methane gas must already be in the box. It will not occur every time the methane gas in the box is ignited - that will depend on the disposition of the methane gas in the box, but more importantly, on the path over which the escaping gas flame is to travel. Close the box and it will not occur.

It is a quirk of fortune that the pattern was left at all. However, once it is evident, it is as strong from an evidentiary point of view as if what made it left its visiting card or its fingerprint - at some time the necessary methane gas was there and it was ignited.

I am therefore left, as a result of the whole of the evidence, with the conviction that the explosion began by an ignition in the fan starter-box. I do not suspect that the deputy's lamp contributed in any way to the explosion. Indeed, having studied in detail the investigation of safety lamps, their defects and their inability, despite those defects, in most cases to propagate flame externally, I believe that reports of overseas explosion in mines where safety lamps have been indicted as the cause, should be treated with great reservation now: they would need careful re-examination to determine what was really amiss with the suspect lamp and how it was known that it propagated externally.

It is proper before I come to my general conclusions in this Inquiry that I should examine more carefully the part played by Mr. Oldcorn. It will be recalled that on the evidence as to his movements he could not have arrived in 'K' panel before approximately 10.40 pm., possibly 10.45 pm., the explosion occurring at 11.00 pm. At first, hearing the evidence, I wondered

whether there was some link between his arrival and the explosion; but at that time there was only speculation available to me. He had been asked in Mr. Metcalfe's note to see to three things in particular:

(1) Whatever else he did, to make sure 'A' and 'B' neadings and **4** cut-through were stone-dusted.

(2) To see Walsh (Vic) about the changeover.

(3) To get both units (the Marietta and the Joy 10 CM) working on that shift if possible. He could, if necessary take men from south-west.

In a nutshell, he was to ascertain from Walsh how far he had reached with the changeover He did this apparently at 6.50 pm. At that time Walsh would know the state of the overcast (and no more) if somebody had told him. The essence of his remaining instructions was to make sure about the stonedusting and to get production started. Tnere is evidence that he called out and instruction to Rawcliffe about the stonedusting -

Mr. Fisher tells us that. It was a job which in the ordinary course of events could be seen to by the deputy, without managerial supervision. He must have calculated that he had plenty of time to get down in 'K' panel the last part of the changeover must necessarily be unfinished - that is, coupling up and hanging the cables - whatever else remained to be completed by way of brattice alterations.

He appears to have spent some $2^{1}/_{2}$ hours in control. The suggestion is that he had a cup of tea there. There is evidence that he made and received no phone calls. He therefore knew of nothing which urgently required his presence in 'K' panel. He allowed himself $^{1}/_{2}$ a shift for his visit there.

A note found in his pocket is his version of the undermanager's instructions. It reads:

"K S/D Both Hdgs & No. 4 C/T

Vent change

Work Both units.

Stop S/W if Nec'y"

Then follow a series of notes about materials and transport. Against "K" he had wirtten "half FT (flat-top) Steels".

This is not the picture of an assistant undermanager who either knows or imagines that anything may be wrong in 'K' panel. In evidence Mr. Metcalfe expressed the wish that changeovers in ventilation be carried out under the supervision of an assistant undermanager, although the general attitude of the management is that such work is well within the capabilities of the ordinary deputy. Mr. Oldcorn apparently shared with Mr. Walsh the belief that an assistant undermanager was not required. There is really no evidence of what he did when he arrived at 'K' panel. It may be that the fan had stopped and the electrician called before he arrived. Equally, depending on the nature and length of the stoppage, the fan may have stopped while he was there.

I find it difficult to believe that he did not take some methane gas readings while he was there. If he did, he may well have found some disturbing quantities. It is difficult to imagine both him and Rawcliffe testing for methane gas in the stub. At the time of the explosion, Oldcorn was outbye the stub, not so far from the fan.

There is a picture which presents itself to my mind which is completely consistent with innocence on the part of Mr. Oldcorn and which seems perfectly possible. It may well be that the fan had already removed part of the accumulated methane gas before it stopped. The electrician was called and opened the starter-box. In the meantime Oldcorn arrived. The electrician put the door back on one bolt and started the fan from outside the back plate, drawing methane gas out through the exhaust. Until that time Oldcorn did not know that the power was on to the fan. With the fan running, he knew, of course. If he then told the electrician to stop the fan immediately, after methane gas had entered the starter-box, the spark made on breaking the circuit would have ignited the methane gas and caused the explosion.

This is an account which appears logical to me, because it does in fact explain the lingering of an inflammable methane gas/air mixture in the starter-box and in the tubes, right to the end of the exhaust. hasten to add, however, that the evidence is quite equivocal.

SUMMARY

In summary form, therefore, I answer the question which is directly put to me, namely how the disaster at Appin Colliery came about, in the following manner.

The Colliery was driving a 3-heading panel known as 'K' consisting of 'A' heading, 'B' heading and a heading known as Longwall 8 maingate. 'A' heading was the centre heading. All 3 headings had reached a cross-road, known as 4 cut-through. 'B' heading was driven some 70 metres beyond the cut-through. Longwall 8 maingate was a short distance beyond the cut-through. A start had been made on 'A' heading beyond the cut-through, with a Marietta continuous miner, and an auxiliary fan in 4 cut-through. 'B' heading stub was on brattice ventilation, stretching from near the face, diagonally across 4 cut-through, to the nearby corner of 'B' heading. Longwall 8 maingate was also on brattice, although trouble was experienced with that brattice because of pressure from the exhaust of 'A' heading fan.

Both 'A' and 'B' headings were intake headings. The maingate was a return heading and separated from 'A' heading by 2 brattice stoppings in 3 cut-through, one of which was ineffective. It was desired (1) to change 'B' heading to a return air heading, leaving 'A' heading as a sole intake. (2) to work 2 continuous miners as nearly simultaneously as possible.

The alteration of the system involved the introduction of a second fan for 'B' heading, where a Joy continuous miner and a shuttle-car were situated. This also involved the installation of a second load centre. All power was linked to transformers in the 'A' heading crib room. It was planned to erect an overcast at A3, leaving 'A' heading intake air intact. The return air from the altered 'B' heading would then flow over the overcast into the maingate heading. A stopping was to be erected in 'B' heading outbye 3 cut-through, blocking off intake air. The brattices in 3 cut-through between 'A' heading and Longwall 8 maingate were to be removed to induce 'B' heading return air to flow through 3 cut-through. Cables had to be retrieved from 'B' heading and hung in 'A' heading. Other

installations normally found in intake airways had to be re-installed in 'A' heading.

The management was concerned to supply enough air for 2 fans. For this purpose, 'E' Panel in the mine was stopped. By 23rd July, the day before the explosion, a reading showed 26m^3/sec., which the Colliery considered sufficient for the 2 Richardson fans, which they incorrectly believed drew 18,500 cu. ft./min. each on open circuit. It was planned that the ventilation changeover should take place on 24th July. No specific shift appears to have been nominated, because the changeover waited upon the completion of the overcast. There was no guarantee that the air quantity would be available on changeover to a single intake, or would not be affected by factors such as a single intake.

A second deputy was introduced into 'K' Panel on the afternoon shift to supervise the work necessary for the changeover. His name was Schuster. The Assistant-Undermanager was Mr. V. Walsh. The panel deputy, O'Connell, received no communication that the changeover was in fact to be completed on his shift. There was no communication between Schuster and O'Connell about Schuster's progress.

For the shifts of the day previous and the 24th itself the deputies were troubled by accumulations of methane gas in 'B' stub. The stub was 70 metres long. The brattice, upon which the stub depended wholly for ventilation, was continuously and seriously disturbed by men and materials passing through. The undermanager was aware of the danger and had issued a warning that care must be taken with the brattice. This warning was not properly heeded. The last time O'Connell saw the brattice and/or tested for methane gas in 'B' stub was 4.00 pm.

Tne overcast was finished and the stopping erected in 'B' heading, the latter potentially weakened because it was stapled on the wrong side of the props. Schuster noticed with concern a flow of air towards 'B' heading from 3 cut-through for which he could not account and a strong leak in the new stopping. He did not remove the brattices in 3 cut-through.

'B' heading beyond the stopping was therefore neither an intake (except for leaking air) or a return. The stub was practically, unventilated. The make of

methane gas was estimated at $1^1/_2$ cu. ft./min. at least. Methane gas must have built up quickly and layered. This position was allowed to remain until the new shift reached the face - at about 7.30 pm. The earliest the new deputy, Rawcliffe, could have taken down the brattices was about 7.40 pm. The lack of ventilation therefore must have lasted at least 30 to 40 minutes. It could have lasted until the explosion, but there is insufficient evidence to say this positively.

The management desired the ventilation change to take place as soon as possible and production with 2 miners to commence almost immediately afterwards. There was no period of time allowed to supervise the efficiency of the change or its effects upon the general ventilation of the panel. The management's viewpoint was that any failure or lack of efficiency was well within the competency of any ordinary panel deputy to remedy, particularly with the supervision, if necessary, of an assistant undermanager. It should be noted that neither officer was provided with an instrument to measure air delivery. He relied upon a handful of stonedust thrown into the air, or a piece of chalk flicked with his thumbnail, to indicate air drift and its apparent rate. There is thus no record of

(1) the removal of the 3 cut-through brattices at any time, or, if removed

(2) a deficiency of air quantity available due to
   (a) a sudden change outbye the panel;
   (b) substantial leakage of intake air into the adjacent return system through the new brattice stopping and in particular, the newly-built overcast, which yet remained to be sealed, or the new brattice failing substantially.

At the time of the explosion 'B' stub had been changed from brattice to fan ventilation. This could not have happened in any case until at least 9.30 pm., probably later. Even on continuous effective fan ventilation the build-up of methane gas at the end of the stub must have been a matter of substantial concern. A length of brattice in 4 cut-through was removed. However, at some stage the fan stopped, after running ineffectively in reverse phase. It is not known whether, after this fault had been corrected, the fan again

stopped. It probably did, or else it could not be re-started easily, because the electrician had started it with the flameproof enclosure still open, having kept it in place with only one stud. Methane gas in the fan starter-box ignited and propagated to the outside via methane gas nearby, most probably in the vicinity of the exhaust. The flame was conveyed by the vent-tubing to the concentration of methane gas at the closed end of 'B' stub, causing rapid deflagration and explosion. 14 men in the panel died as a consequence, one outbye was burnt and there was widespread damage.

My finding necessitates a finding of methane gas in the starter-box and around the back of the fan. I am unable on the evidence to say in any precise manner how this collected, there being no eye witnesses and the evidence itself having been largely destroyed by the explosion. The following means are, however, open on the evidence:

(1) The failure of adequate ventilation of 'B' stub, because of the non-removal of the 3 cut-through brattices.

(2) A possible failure of ventilation due to an occurrence such as a fall in a stopping outbye.

(3) The substantial leakage in the overcast and through 'B' heading stopping creating a serious deficiency of air available to the 'B' heading fan.

(4) The failure, deliberate or accidental, of the 'B' heading stopping.

In this account I have said very little about the men who died. After all, it is their death which has rendered this Inquiry necessary. A Court must look at such matters unmoved by emotive considerations which may lead it astray; that is, the examination, in order to achieve a proper assessment, must be cold and objective.

Tnat does not discount in any way my personal feeling of deep sorrow that these lives have been lost and that the families and friends of the unfortunate men, as well as the community itself, are compelled to bear that loss.

However, the Court cannot proceed to do justice to the past and to the future by adopting the role of a mourner. In fact its greatest contribution is the

spelling out of what should be done to avoid such a loss occurring again. I am certain that even those close to the men who have died in this disaster would wish that I at least make such an attempt.

The mining of coal in pits can be an undertaking fraught with danger. It need not be, if proper safeguards are adopted. This Court should aim at so regulating the conduct of coal mining that men may enter mines to work without fear of death or injury. It may never achieve complete success; however, it can move a long way towards that goal, if only it instils the lesson that in coal mines safety is paramount. I am sure that the whole industry, colliery owners, officials and mineworkers share my belief.

It is in this spirit, then, that I make my recommendations for the future. It should be remembered that I have had the privilege of presiding over what has probably been the most intensive investigation into explosions in the history of the coal mining industry in Australia. Many experiments have been conducted, research here has been undertaken and overseas knowledge has been studied and collated. A variety of witnesses as to opinion and fact have been closely examined. The whole of the evidence has been tested by highly qualified legal Counsel and experienced men in the industry itself.

OBSERVATIONS AND GENERAL RECOMMENDATIONS

I make the following comments about mining practices which have become evident during the Inquiry.

The Colliery itself faces increasing methane gas problems and these will tend to increase with further mining. The management has recognized this situation and has already started a programme aimed at meeting these problems. However, the methane gas problem is not confined to Appin and will become apparent to most deep-mining projects in this State and elsewhere. The Department should act now through its Inspectorate to meet these difficulties before they occur, since they are largely predictable, by inspecting and advising collieries as to new techniques and the like, with which the Department is already familiar. Overseas investigations should be undertaken. In this context the economic importance of coal nationally should be kept to the forefront. The latest figures available to me, those

for the year 1979, show coal as Australia's second greatest cash export income earner. New South Wales earns a great share of this. It must be remembered also, although this is outside of the terms of my Inquiry, that methane gas is now largely allowed to waste, whereas its entrapment may well go part of the way to meeting the cost of new measures to combat methane gas problems in mines.

Deputies at Appin appear to allow substantial quantities of methane gas to collect in standing places, upon the basis that there is no danger if there is no apparent source of ignition and no great problem if they do not have stop mining. The management regards methane gas problems of this kind as inevitable under the conditions which exist at Appin. This in itself is a dangerous attitude, leads to complacency and usually is in breach of the Act. The attitude must be changed. It has been permitted to continue by Inspectorial tolerance. Hand in hand with this principle is the fact that the management can easily be misled by its own deputies, if it chooses to rely upon their General Rule 4 reports. These are vague in the extreme and give no real indication as to actual methane gas conditions or ventilation. Mr. Fisher himself said that he was not too happy with them. The form itself is a limiting factor with space only available often for minimum reporting. This form should be revised. A deputy should be asked to state not only his methane gas reading, but also the real location of its issue. If one relies upon the reports, one has the feeling that the safety duties of the deputy are perfunctorily performed. It is as if the deputy is going through a ritual. There was little evidence that the deputy in fact did more than this, although he spent ample time in solving production problems. This is not true of all deputies, of course. I believe, also, that most deputies are dedicated men, and in time of emergency could be depended upon to act conscientiously and efficiently. I feel, however, that there should be some check upon the deputy's safety inspections. The ideal officer to perform this task is the Federation's Check Inspector, who is ordinarily fair and efficient, and brings to light conditions which may remain hidden. However, there are not enough of these gentlemen. I believe that their number should

be increased. I had raised as a possible solution the appointment of a Federation man to every shift with sufficient "pit experience", but without the theoretical knowledge tested by examinations, to act as a kind of deputy of second rank, as it were. The idea was not popular with the representative of the deputies or with some other advocates. I still think it is worth considering.

At Appin deputies were not issued with metnanometers - assistant undermanagers were. The deputy had to rely upon his safety lamp. Mr. Kininmonth revealed that he used his methanometer for methane gas measurement. He carried his safety lamp as a badge of office. Appin colliery has, since the Inquiry began, issued all its deputies with methanometers. 1 do not recommend that the safety lamp be withdrawn at this stage. It is the only feasible measure for a deputy of the lack of oxygen. This condition may, of course, change. It is of little use as a means of illumination and has been wholy replaced for the ordinary miner, by his battery-operated cap lamp. Without a methanometer, however, the deputy cannot measure methane in quantities of less than 1.25%. Thus he cannot tell if the mine is complying with the Statute in regard to quantities in the relevant intake airways where the statutory limit is 0.25%. The deputy must be given a methanometer in addition to his lamp. However, there is a danger here. If the deputy always relied upon his methanometer, he could be mistaken. Experience has shown that these can be unreliable and can go out of calibration easily. A weak battery will produce a false reading. The methanometer must be continually serviced and kept in order, and delays often occur among those companies which offer such service. Accordingly, the deputy's prime measure should still be the lamp, with the methanometer available as a check, particularly when no methane gas is found on the lamp. The Garforth bulb is not a check.

The management seemed to regard ventilation questions, and in particular, ventilation changeovers, as simple matters, well within the capabilities of deputies and assistant-undermanagers. I feel that the hardest lesson which the management will have to learn from this Inquiry is that while these may be simple to

managers who have an overall survey of operations and great experience, the complications which may occur may not be apparent to those below them. It is not simply a matter of putting up a stopping here and pulling one down there, as these men appeared to think. No manager or undermanager can be expected to be at the mine the whole time and supervise every new operation. They are entitled to rely upon officers who they feel are competent. I would recommend the appointment of a ventilation officer perhaps with a part-time but prime responsibility - whose duty it would be to supervise the whole question of ventilation in a mine. This office is not new in countries abroad, where at times a statutory ventilation officer for a district containing a number of collieries has been appointed. At this stage my recommendation does not go as far as this. But I regard ventilation problems as specialist problems; ventilation in a particular district may involve ventilation in the whole mine - as it really did at Appin. It should not be a duty distributed over a number of assistant-undermanagers and deputies.

I feel that after a ventilation changeover such as that performed on this occasion, production should temporarily cease, and power be cut off to the section. it would thus be preferable that changeover should occur during the weekend. A period of waiting-time and subsequent testing, together with any degassing necessary should ensue before production recommences under the new ventilation system.

I have already expressed deep concern at the tolerance allowed by the Inspector of Appin's continual breach of statutory requirements relating to methane gas and at the statement that the Inspectorate was enforcing an anticipated new level only. Such a position is intolerable in any law-enforcement body, and no Judge should hesitate to say so. Exemption provisions may be invoked, but no exemption was applied for by Appin. The system of policing an Act designed to keep coal mines safe must be kept as tight as possible. Otherwise the Inspectorate may find itself in a situation where it is blamed for tragic consequences - a situation from which a former inspectorate escaped through a somewhat benevolent attitude on the part of one tribunal at the beginning of this century (see Mt. Kembla Disaster

1902). I have already referred to the fragmentation of testing on behalf of the Inquiry between the local Inspectorate on the one hand and Londonderry and Lidcombe on the other. This type of situation is most undesirable, because it can always lead to accusations of apparent partisanship, undisguised by the fact that another Departmental investigator is called in to observe or otherwise take part. All such experiments should be Departmentally official, permitted and conducted under the supervision of one director.

I raise also what is probable well-known to the Department, the dearth of competent Inspectors to perform the whole task adequately. Inspections sometimes are separated by months and then do not involve the whole mine. There appears to be a totally inadequate number of Electrical Inspectors. The amount of paper-work alone for a local Inspector must be enormous. No record of the result of an inspection seems to be left at a mine. Tnis, however, is a subject for Departmental management.

A complaint was made to me at the hearing by the advocate for the Federation that exemptions from provisions under the Statute were communicated to the colliery management, but not to the check inspector. As a result the latter officer wasted his time to prove a breach, only to be told for the first time afterwards by the management that it had an exemption. If this is correct, understandably the check inspectors feel that they are being treated with comtempt. The situation should be remedied immediately by the sending of a duplicate copy of the exemption to the local check inspector.

Much debate has taken place before the Inquiry and at the Inquiry as to whether the percentage of inflammable gas mentioned in General Rule 1(e), representing the percentage found in an intake air-way so that it should be deemed "normally kept free from inflammable gas" should be raised from .25% to a level of .5%. Mr. Mould said he understood that the Inspectorate was applying this new level in the belief that the Act was to be altered accoringly. Mr.Kininmonth thought that the level should be .4% with a higher tolerance. There are two factors of importance:

(1) The safe limit. The intake air must contain a sufficiently low percentage of inflammable gas to ventilate the working-place so that it finally contains no more than 1.25% of such gas.

(2) The mine must be able reasonably to comply with the provision.

I believe that the first factor takes complete precedence over the second. In view of my findings, I feel that it is dangerous to raise the present statutory limit of .25%. However, I do conceive of situations where some tolerance may be allowed, as long as ventilation prevents an excess of the safe limit of 1.25%. As a result of the Appin experience I believe that the strictest control of methane gas percentages in intake airways should be maintained. If tnere is any tolerance, it should be limited to a low departure from the statutory provision and only given on written application to the Chief Inspector for exemption. This exemption should only be given on the Colliery's showing that a raising of the figure will still result in adequate ventilation within the meaning of the Act, and shall at all times be subject to review by the Chief Inspector. Any colliery seeking exemption should be warned that a discovery that face ventilation standards have not been maintained will have its exemption revoked.

I feel it would be an advantage for the realistic application of the Act and for the assistance of the Chief Inspector, that collieries be graded in terms of gassiness. For example, Appin and certain adjacent collieries would fall within the category of the most gassy. At the other end some collieries would suffer from no such problems. Between these extremes there must be a medium range. The problems in all of these ranges is not the same and the Inspectorate would do well to pay particular attention to the policing and solution of the problems of the more gassy collieries. I say no more than this, but commend this view to the Chief Inspector for consideration, so that he will judge whether there be any advantage in the concept.

I have already dealt with the subject of the maintenance of oil flame safety lamps. I specifically reommend that every lampman be supplied with an illuminated magnifying glass for the inspection of faults

in gauzes. I also recommend that the stock of lamps at all collieries be the subject of periodic checks by Mines Inspectors and Check Inspectors. Consideration should be given to the development of alternative gauze materials and the setting up of a standard section by the Mines Inspectorate. There appears to be a need for consultation and investigation of overseas methods of improvement in regard to oil safety lamps, and the possible development of an alternative combined accurate methane measuring device and oxygen detector.

In the more gassy mines there needs to be a requirement that an automatic monitoring device of a sufficiently portable nature be installed at strategic points in headings to give a continuous reading of methane, carbon monoxide and oxygen. It would be moved from time to time as drivage progressed and it could be located so that traffic did not interfere with it. An added advantage would be a device which gave an alarm at certain levels of methane gas - preferably a flashing red light.

I am concerned that tradesmen (fitters, electricians and the like) who frequently work alone and between crib times carry no lamp or methanometer which can warn them of the presence of methane gas. The same is true of ordinary workmen, of course. They are compelled to rely upon a deputy who may not have inspected for some time a place where they are working, or may have missed methane gas on a routine inspection. A workman erecting a steel, for example, can easily have his head close to a layer of methane gas at the roof, with no indication of its presence. Appin so far has been lucky enough not to have areas of roof silica which are subject to chance frictional incondive sparks. These areas are frequent in nearby mines and are likely to be encountered in time, even at Appin. I believe that it would be a great advantage in maintaining safety for tradesmen and workmen if they were equipped with an automatic monitoring and warning device. At an early stage during the Inquiry I mentioned the possibility of a lightweight monitor to be worn at cap level which emitted a warning sound at a predetermined level of methane. I received a number of brochures which portrayed equipment which was unsatisfactory from the point of view of weight. Finally a Polish group

exhibited to the Inquiry at the Rescue Station equipment which seemed to meet the conditions. On reflection, however, I realised that in the noise of mining the audible alarm which it emitted might well be missed, or a workman might continue to work, deliberately ignoring the alarm. A visual alarm which prevented the continuation of work would be much preferable. I now have received some specifications of a Russian device. It is the CMC "Mayak" Methane Monitor which works with the miner's cap lamp and flashes it on and off when the concentration of methane reaches the maximum permissible level. It weighs little more than the present battery and cap lamp combination. There may be other makes of a similar device. I recommend that this avenue be investigated and if a suitable device of this kind is available and is approved by the Chief Inspector, that it be made a compulsory substitute for the ordinary cap lamp.

It appears that there is a grave danger in driving a lengthy stub in a gassy panel and leaving it stand on brattice ventilation alone particularly on the intake side. This is an area which needs urgent attention and no gassy drivage with a dead end should exceed a predetermined limit in length before being required to stand on auxiliary fan ventilation unless the mine has been exempted from this condition by the Chief Inspector for good reason (for example, no serious methane gas problems). As a suggestion only I put forward the figure of 50 metres as the limit. The lack of fan ventilation takes place usually on weekends, when there is no production. Fan inspection, of course, is a necessity for fan ventilation. However, these difficulties are of little moment compared with the danger of methane gas accumulations in new headings with defective ventilation problems such as led to the explosion at Appin.

I have already in the body of my Report dealt with possible improvements to stonedusting methods and to stonedust and water barriers. I have been asked to make a special recommendation that the Regulations make provision for not removing any such barrier once it has been placed in position. The practice at Appin was to remove outbye barriers once the development had reached a point considered sufficiently far removed inbye. It

is suggested that a proper inference can be drawn from the evidence that a water barrier in Longwall 7 maingate did much to check the explosion and so avoided complete disaster.

In an endeavour to avoid present dangers which can arise through the use of electrical equipment there is a need for proper policing of those parts of the Act and Regulations which deal with the opening of flameproof enclosures under voltage, as well as the failure to remove power from equipment such as miner cables and machines within the prescribed limits when methane gas nas been detected. I have already dealt with those flagrant breaches of such provisions which were apparent in 'B' heading stub. I am certain that these were not isolated cases and that risks were taken although lip service was paid to safe practices. It is impossible to believe that what went on in the night of 24th July was the first instance of the kind. Examination of the electric equipment found after explosion showed unapproved modification at times of approved equipment, which may or may not have been safe in the circumstances, but which indicated little regard for Departmental requirements. A vivid instance of this is the fan starter-box itself, with a number of modifications which received no approval, including the removal of one step-down transformer and the defeating of the thermistors. Yet this fan had undergone a visual inspection and been passed for use in 'B' heading a short while before. This attitude of carelessness for regulation is in line with some of the other practices to which I have already referred.

Regulation by legislation is required for a breaker system to prevent any flameproof enclosure being opened without the automatic disconnection of power. This kind of device and the necessary circuitry are already known to the Departmental electrical inspectors and it should be an essential requirement. There is also a grave necessity for an interlocking circuit which will automatically trip the miner if the auxiliary fan stops. The situation in 'B' heading was that with no ventilation the miner was left with power on in the "run" position. It could happen that the miner continue cutting coal in a heading for some very short period, ignorant of the fact that the fan had stopped outbye

- a situation fraught with danger, until something like a build-up of coal-dust allerted the miner driver. Even better would be the cutting off of all power to the Section.

Advocates addressing me have expressed dissatisfaction with the qualifications of two distinct classes of mining people:

(a) the man with a certificate from abroad who receives endorsement of his certificate of competency without the necessity to show sufficient local competency;

(b) the method of recruitment of "new starters" As to the latter class the Federation believes that the usual induction of some 5 days is not enough to fit a man to work at the face. It argues strongly that Order No. 34 of the Joint Coal Board, which deals with the subject, is inadequate to provide men who can be entrusted to engage in safe mining.

I have been asked by the Federation to use tnis Report as a vehicle for a request by this section of the indsutry for a further Inquiry which does not arise directly out of the Appin disaster. I state the proposal and the argument used to back it, but make no comment upon it. I regard it as purely a policy matter for the Government.

The proposal in "that a judicial inquiry take place into the safety of the coal mining industry in New South halos". It would appear that the argument is used that the fatalities in the Appin disaster are only a fraction of the total number of accidents occurring annually in N.S.W. coal mines, most of them "avoidable" accidents. A claim is made that the number of accidents, including fatal accidents, is increasing. The following figures are put forward in support: In the year 1978-9 there were in N.S.W. 10,000 accidents the subject of compensation, injuries ranging in duration from one day to permanent injury. The estimate for 197980 is that this number will increase by 8%.

The total workforce in the industry is some 15,000 people, with 10,889 working underground. Compensation for the year ending 1979 amounted to a paid-out figure of $16,383,000, with an outstanding liability of $8,549,000, a total of nearly $25,000,000. The insurance policy oremium was $25,633,000, representing 9.7% of the gross wage paid.

The evidence reveals that the self-rescue equipment carried by the men (introduced after the Bulli disaster) was used successfully at Appin. I am still concerned, however, about the discomfort self-rescuers cause to those wno are forced to use them. The high neat they can produce in the mouth and throat of the wearer in adverse conditions may well tempt a workman under stress to remove the equipment from his face only temporarily in carbon monoxide and thus to die almost instantaneously in a high concentration. Prolonged investigation should be undertaken to find, if possible, effective equipment without this disadvantage, or to discover a modification of the equipment itself which will offer the wearer some protection against generated heat. In the meantime every man in the mine should be taught by practical experience what to expect when wearing a self-rescuer. It is too dangerous, of course, to subject him to actual carbon monoxide. However, causing a man to wear a self-rescuer in extremely hot air, possibly through dense smoke or coal dust, may well give him the necessary experience. I am sure that Rescue Stations or the Department's Testing Centre can devise a situation of this kind, to which all miners would be exposed.

Now that the explosion gallery has been built at Londonderry, the Testing Centre can undertake much needed experimentation under proper conditions instead of devising makeshift controls for its experiments. The Department has a valuable asset which outlives this Inquiry. It would be a pity, however, if experimenting remained its sole use, even though this ranks highest in the gallery's importance. It should also be used as a teaching aid for men in the industry. I am aware that already some films of fire and explosions exist for this purpose and are used for induction courses and in other ways. I see the Testing Centre's role in developing training aids of this kind, preferably on video cassette, which can be used at mine sites. Thus every miner should be shown the fire and explosion potential of a collection of methane gas. Every man should be made acutely aware of the danger of incendive sparks in equipment, and frictional type ignitions as well as static electricity caused fires from the use of compressed air. The only answer to ignorance of

danger is, of course, awareness, and the Testing Centre can play a most important part in making men aware. In saying this I include the co-operation of the researchers at the Department's Chemical Section at Lidcombe, who could work together with Londonderry personnel on projects of this kind.

The Coal Mines Regulation Act has for some time been undergoing a process of complete revision. Submissions have been made by various interests and committees have sat to discuss these. The result will obviously be an entirely new Act, with the retention of such parts and principles of the present Act as are obviously the basis of regulating safety conditions in coal mines and have proved themselves to be successful pieces of legislative enactment over the years.

I have been privileged to see what is known as "the Third Draft" of the Act, which almost brings the process of revision to completion, and I have been invited Departmentally to make comments upon it. My own review of what has been accomplished by others who nave toiled to produce it is now complete.

Some of the matters in my Report are obviously public statements of either principles to be embodied in the Act and its Regulations, or matters which should be included in any revised enactment. I have at times opposed drastic change. For example, I have commented already upon the raising of permissible levels of inflammable gas (firedamp) in intake airways.

I do not believe that I should include the remainder of my conclusion in this Report, but feel that they should reach the Minister and his Department in a separate document by way of an addendum to the Report itself and distinct from the subject matter of the Report. I have prepared such a document, which I forward to the Minister, together with my Report. I have decided to adopt this course for a number of reasons, not the least important of which is that the Third Draft is not a published document and it is not part of my brief to see any part of it made public at this stage. My own references to specific sections and Regulations by number with cross-references to other parts of the Draft would in any case be meaningless to people who have not been supplied with a copy.

Several months ago, when I began this Inauiry, I believed in my innocence that the answers would readily be seen and that this Report would be completed much earlier. I saw the need for expedition and urged upon all parties the principle that there should be no unnecessary delay. As a result, Counsel gave up well-merited vacation time and other commitments with little demur. My own ordinary judicial list has been suspended, and my Chief Judge has been most understanding and co-operative.

Nobody begrudges the time and effort spared upon what has become known as "the Appin Inquiry". My great regret is that it could not humanly have been completed earlier. My great hope is that it will be of benefit to the people engaged in this industry, which is of ever-increasing importance to this country.

I have to honour to be, Sir,
Yours faithfully,

A. J. GORAN

Judge,
Court of Coal Mines Regulation.

APPENDIX

GLOSSARY

The terms and expressions used in the coal-mining industry do not bear uniform meanings in all mines. They may vary from one English - speaking country to another. They also bear different meanings in the same country, depending upon the district wherein they are used. They also have cnanged in meaning over the years. Many words are invented by men in a particular mine to suit the operation which they are performing. Some owe tneir derivation to the past, having been handed down from one generation to another - this appears to apply particularly to terms of Welsh origin.

However, there are some standard expressions which have become enshrined in legislation.

In this glossary I attempt to give to words the meanings which have been ascribed to them during the Inquiry. I do not vary the meaning which occurs in the Act or its Regulations.

My purpose in providing this exposition of meanings of words used is that I would not wish to have those who read the Report bewildered by terms which have little meaning for them. I am also conscious of the fact that the published document may find its way into the hands of those unfamiliar with coal-mining, as well as those who are experienced but who must know the sense of expressions as they are employed in what I have to say.

Finally, as I nave indicated above, I make no claim to any universal accuracy for this Glossary.

Arcing : A luminous discharge (consisting of a column of ionized gas) between two separated points of one or more conductors on completing or breaking an energized circuit (for example, a spark gap).

Belt Conveyor : A moving, endless belt on which coal is loaded for carrying from one point (e.g. a Hexham feeder) to another (e.g. the surface).

Brattice : Has other meanings, but as used here is brattice cloth , used mainly as a temporary air stopping or diverter. Now made of flexible plastic material, (e.g. fibreglass).

Cinter-ring (Mis-spelt in Reports as "sinter-ring") a ring that fits over and holds the wick-tube in an oil flame safety lamp.

Continuous miner : A large, heavy mining machine which can cut and load coal.

Crib, crib-room : A meal and the section of the mine in an intake airway set aside for the partaking of the meal.

Cut-through : Passages or connecting roads between parallel headings.

District : A division or section of a mine so planned as a separate unit for the purpose of ventilation or supervision or electrical circuitry.

Drivage : The length of heading driven, usually by a particular time.

Earth-leakage trip : A device which disconnects the supply if the voltage on non-current carrying metalwork or the out-of-balance current in the supply due to leakage exceeds a pre-determined value. It does not require a low-resistance connection with earth.

Face : The surface or working place from which coal is being extracted.

Firedamp : Inflammable gas, mainly methane, but containing smaller quantities of other gases, such as propane, or inert gas, such as nitrogen. For practical purposes, firedamp is synonymous with methane and in common with experts who have given evidence, I have used the two names interchangeably.

Gate-end box : An electrically operated contactor switch interlocked electrically with a main isolator in a separate compartment. The contactor can be controlled locally or remotely. The remote control system is used also to interlock electrically the cable plug so that if this is withdrawn the power supply is cut off and the contactor trips.

Goaf : The worked-out section of the mine, frequently the roof being allowed to cave in. Often goaves are the source of flammable gases, which tend to collect in these areas. Probable derivation Welsh -"ogof": a cave.

Heading : A horizontal roadway or passage driven - either through coal or stone.

Hygroscopic : Readily absorbing moisture from the air.

lnbye : In relation to a given point, further away from the shaft.

Intake air : Fresh air introduced into the mine (through the downcast shaft and/or the drift).

Lagging : A flattish piece of wood or other material) used for various purposes, such as wedging timber or steel supports against the floor.

Layering : The tendency of gas with a specific gravity different from air to form a layer against the roof (e.g. methane) or in cavities, or against the floor or lower parts of the workings (cf. "Illawarra bottom gas"). Layering is opposed to mixing with air.

Maingate : The heading which forms the principal means of access to a face or longwall of coal. It is, when a panel has been completed, often used as the heading along which the coal is conveyed. Normally, at this stage it is an intake airway.

Man-car : A vehicle used for conveying personnel in a mine.

Marlin : Bolt rope, the name apparently originally derived from the naval term "marling" or "marline", the ordinary name for bolt or steel twine.

Methane monitor : A device for measuring quantities of methane present, which may be portable in the sense that it can be moved from one place to another. It is located at appropriate places as a methane indicator and has a calibrated scale. For example, a continuous miner must carry a methane monitor which will trip the power to the machine at a certain level. A monitor may give a visual and/or audible alarm.

Methanometer A device which is portable in the sense that it is carried by the operator who tests for the presence of methane. The quantity of methane is measured on a calibrated scale.

Outbye : In relation to a given point, in the direction closer to the shaft.

Overcast : An air crossing in which one airway passes over another airway which continues on its normal level. The airways at the crossing are made airtight with masonry or concrete lining to prevent leakage from the intake into the return airway.

Panel : A section of the mine, isolating coal, usually consisting of more than one heading, and carrying both intake and return air for ventilation purposes.

Pillar : An area of coal left to support the roof. In bord and pillar mining pillars are extracted later.

Return air : Air which has circulated through the workings flowing towards the upcast shaft where it is drawn by the main ventilating fan system.

Self-rescuer : A respiratory apparatus which can be used by a miner after explosion or fire, to prevent breathing of carbon monoxide by converting it through chemical change into a non-noxious substance. It is portable and is carried attached to the miner's belt.

Shuttle-Car : A low, rubber-tyred vehicle designed for use with power loaders to span the gap between the miner or face and the main haulage. Carries coal from the continuous miner, but is also used at times to carry other materials for short distances.

Sintered : Converted in cinders (frequently caked).

Split : A current of air which has been separated from the main intake to ventilate a district in a mine. The term is sometimes used to describe the point of separation of air in a smaller intake airway.

poiler : A fixture to act as a baffle behind the exhaust of a fan to oppose the velocity pressure of the exhaust when the fan is operating and so prevent recirculation of exhaust atmosphere. It may be made of brattice, leather belting and the like.

Stone-dust : An inert dust, spread on roadways, ribs and at times, the roof, as a defence against the danger of coal-dust explosions. It must be of a type that does not cake in mines. Finely ground limestone is the most commonly used in this State. Gypsum can also be used.

Stopping : A brick, stone or concrete partition erected in a roadway which is not needed for hauling or travelling, to prevent the leakage of intake air into the return airway. Stoppings may also be made of plaster board, or, if temporary, of brattice cloth.

Stub : This word is not commonly used. In the present Inquiry it refers to that part of a heading which has a dead end and which has been driven beyond the last cut-through.

Tailgate : I found that a number of experienced mining men could give no precise definition of this word. It is a subsidiary gate road to the face. Commonly it acts as *a* return airway.

Tramming : (A mining machine) Moving the miner into a position.

Tube-bundle monitoring system : A gas monitoring device, with sensors located strategically through the mine, enabling gas monitoring to be carried out on the surface.

Vent-tube : A ventilation tube, connected to the fan and extending inbye in a heading to remove gas from a place by a fan.

Venturi : A ventilation device operated by compressed air and used for breaking up and moving layers and pockets of gas.