MINISTRY OF FUEL AND POWER

# EXPLOSION AT HARRINGTON No. 10 COLLIERY, CUMBERLAND

# REPORT

On the Causes of, and Circumstances attending the Explosion which occurred at the Harrington No. 10 Colliery, Lowca, Cumberland, on the 9th December, 1946

BY SIR JOHN FELTON, O.B.E.
H.M. Chief Inspector of Mines

*Presented by the Minister of Fuel and Power to Parliament*
*by Command of His Majesty*
*October*, 1947

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THE RT. HON. EMANUEL SHINWELL, M.P.,
Minister of Fuel and Power

9th September, 1947

SIR,

On 20th December, 1946, you directed that in pursuance of Section 83 of the Coal Mines Act, 1911, a formal Investigation should be held into the causes and circumstances of the explosion which occurred in the Main Band Seam of the Harrington No. 10 Mine, Lowca, Cumberland, on the 9th December, 1946, and appointed me as Commissioner to hold the Investigation.

Having held the Investigation in accordance with these directions I now have the honour to report thereon.

By arrangement with Lieutenant-Colonel D. J. Mason, D.S.O., T.D., D.L., H.M. Coroner for West Cumberland, the Inquiry was held concurrently with the adjourned Inquest in The Congregational Church Schoolrooms, Whitehaven, commencing on 25th February and terminating on 1st March, 1947, at which thirty-two witnesses gave evidence.

The appearances were as follows :—

Mr. A. Stoker, H.M. Divisional Inspector of Mines
Mr. G. M. Harvey, H.M. Electrical Inspector of Mines
Mr. P. G. Dominy, H.M. District Inspector of Mines
} For the Ministry of Fuel and Power

Mr. Paul E. Sandlands, K.C. .. .. ..
Mr. G. R. Swanwick (Instructed by Messrs. Brockbank, Helder and Ormrod) .. .. ..
} For the United Steel Companies Ltd.

Mr. W. E. Jones ..
Mr. E. Moore ..
Mr. R. Young ..
} for the National Union of Mineworkers

Mr. Tom Stephenson for the Cumberland Miners' Association

Mr. Barth Walsh ..
Mr. Harry Skerry ..
Mr. John W. Foster ..
} for the National Association of Colliery Overmen, Deputies and Shotfirers

Mr. W. Unsworth ..
Mr. A. B. Dawson ..
Mr. W. F. Richardson
Mr. R. Crawford ..
} for the National Association of Colliery Managers for the National Coal Board

A list of the witnesses is given in Appendix I and a list of the persons killed and injured in Appendix II.

My thanks are due to Colonel Mason for so cordially agreeing to the Joint Inquiry and for his helpful co-operation ; also to the representatives of the various parties, including the Colliery Surveyor, who contributed to the efficient and smooth running of the proceedings, and to Mr. H. Offord who acted as Clerk of the Court.

At the conclusion of the evidence the Coroner summed up at some length and recorded his verdict that the cause of death in each case was due to the result of an explosion of gas on 9th December, 1946, and that the men met their deaths by misadventure.

# I—DESCRIPTION OF THE COLLIERY

The Harrington No. 10 Colliery (at the time of the explosion belonging to the United Steel Companies Ltd.) is situated at Lowca Village about six miles from Workington and three miles from Whitehaven. The shafts known as No. 10 (downcast) and No. 9 (upcast) and of 20 feet and 16 feet diameter respectively, are sunk on high ground within a few hundred yards of the sea under which are most of the workings. The pit bottom is in the Six Quarters Seam at a depth of 648 feet from the surface, and the Main Band Seam at the shafts lies at a depth of 350 feet.

The colliery output which was 5,000 tons per week in 1938 fell to 2,300 tons in 1943 and rose to about 3,000 tons per week in December 1946.

In 1946, altogether 770 persons were employed; 240 (of whom 30 were women) were employed on the surface; 195 were engaged at the coal face and 335 as haulage and oncost workers. The average number employed underground on the day shift was 250, but on the day of the explosion there were 208 at work of whom 53 were in the Main Band Seam, the seam in which the explosion occurred.

Mr. J. A. Nimmo was the General Mining Manager of the Company's Cumberland collieries, Mr. T. J. Hughes was the Agent, and Mr. Frank Graham the manager of the Harrington Colliery. At the date of the explosion Mr. John McCracken was the undermanager, having been transferred three months before from a similar position at No. 5 pit owing to the illness of the regular undermanager.

Supervision in the No. 2 district of the Main Band Seam was by two overmen (day and afternoon) and by one deputy on each shift.

*The Main Band Seam*, which is overlain by a thick sandstone roof, has a total thickness of 12 feet of coal and thin dirt partings, but the roof coal (2½ feet thick) is not worked; the floor is of fireclay and then a thick hard shale.

In this seam four units or districts were being worked, entered from the Main Band engine plane which starts at the Lickbank Junction off the North Plane haulage road at 1½ miles from the shaft and runs west for about a mile.

At this point mechanised mining was begun in 1943 in an endeavour to increase output, four parallel levels (numbered 1 to 4) being started off the Main Band engine plane as development roads and advanced by Joy Loaders and a M. & C. Arc Shearer. Later a trunk belt conveyor was installed in No. 3 level and also chain conveyors. Auxiliary fans were then introduced to ventilate the levels.

From these levels the No. 2 district, in which the explosion occurred, was opened out by five headings at right angles to the levels as shown on Plans Nos. 1 and 2, these headings being commenced in November 1944; shuttle cars were then introduced. The headings were driven at 50 feet centres, with thirlings at 150 feet, and were 15 feet wide by 10 feet high. As the headings advanced pillar workings were opened out to the left (later known as the shuttle car section), but the shuttle cars were withdrawn and this section abandoned short time prior to the explosion, and supports were being withdrawn from it.

The area comprising the No. 2 district was very wet, water raining from the roof in the headings, and it was decided to advance the Nos. 2 and 3 headings (which were rising at about 1 in 18) rapidly to the boundary—fixed by a limiting minimum cover of 240 feet—so as to drain the water from the area, Duckbill loaders with Goodman shortwall coalcutters and Victor drills for simultaneous shotfiring being installed. These headings were reduced to a height of 6 to 7 feet at a point about midway between Nos. 5 and 6 left thirls, and continued at that height, the rate of advance being about 40 yards per month.

No. 1 heading was stopped at No. 4 left thirl, and No. 5 heading having struck a fault was discontinued, the intention being to drive back from the No. 5 right thirl to establish a connection.

No. 3 heading was the haulage road and intake airway in which was installed a belt conveyor fed by a scraper chain conveyor in No. 6 left thirl between Nos. 2 and 3 headings and a similar conveyor in No. 5 right thirl.

At the date of the explosion Nos. 2 and 3 headings were some 40 yards in advance of the last (No. 7) thirl, these workings being about 3 miles distant from the shafts.

When no longer in use the thirls were sealed off by corrugated sheeting covered by brattice cloth. The undermanager said there was a shortage both of bricks and bricklayers and that was the reason brick stoppings had not been erected, but he considered the corrugated sheeting efficient.

*Ventilation* was produced by a Capell double inlet fan, electrically driven, situated at No. 9 shaft with a capacity of 200,000 cubic feet per minute at a water gauge of 8 inches. On the North side of the pit the North Plane haulage road (in the Six Quarter Seam) is the main intake; at the Lickbank Junction about 1½ miles from the shaft the air splits, that to the Main Band seam going west by way of the Main Band Engine Plane. From this separate splits are taken to the No. 4, No. 3 and then the No. 2 units, the remainder passing further inbye to ventilate the No. 1 unit.

The total quantity entering the North Plane as measured on 7th November, 1946, was 61,870 cubic feet per minute. The quantity entering the Main Band on the same date was 41,750 cubic feet. No measurements of the quantities in the separate splits in the Main Band were recorded in the statutory Air Measurements Book (M. & Q. No. 37), but readings for No. 2 District taken from a notebook showed 17,017, 16,744 and 17,876 cubic feet per minute for September, October and November, 1946, respectively.

Plan No. 2 shows the system of ventilation in the No. 2 unit, the district in which the explosion occurred. It will be seen that three auxiliary fans were in use, all of them electrically driven.

No. 1 fan fixed in No. 2 road was of the "Aerex" type (made by Walker Bros.) 19 inches diameter, driven by six half-inch belts (only four in use) with a total capacity of 8,750 cubic feet per minute. Adjustable louvres were fitted on the intake end for air regulation. This fan had approximately 300 feet of 24 inches diameter Meco canvas tubing attached to it for ventilating part of the old shuttle car section of workings recently abandoned and being drawn off.

No. 2 fan fixed in No. 3 road was of the "Aeroto" screw type (made by Davidson & Co.) direct driven at a motor speed of 2,900 r.p.m. Capacity 5,000 cubic feet per minute with 540 feet of tubing 24 inches diameter. Used for ventilating No. 4 heading and the No. 5 thirl extension. No. 3 fan also in No. 3 road was a duplicate of No. 1 and was used for ventilating Nos. 2 and 3 headings.

All the auxiliary fans were kept running continuously when men were at work in the area they served. Normally Nos. 2 and 3 ran constantly from Sunday midnight until about mid-day on the following Saturday. They were re-started on the Sunday morning at about 6.45 and run for some 5 or 6 hours—usually the maintenance engineers were on duty during this period—after which they again stood until re-started by the night shift deputy before making his pre-shift examination for the Monday morning shift.

No measurements were at any time taken of the quantity of air circulated by these fans, and for the reason stated later in this report the quantity in the

intake at 100 yards from the working face was not measured as required by General Regulations.

*Firedamp.*—The Main Band seam is regarded as a fairly gassy one. During the six months preceding the explosion the statutory reports showed the presence of firedamp in No. 2 district to have been reported as follows :—

*4th June*—Afternoon shift inspection from 8.15 to 9.45 p.m. "None except No. 2 and No. 4 High Side off No. 4 Slope. Auxiliary fan out of order 2½ per cent. gas present."

*7th June*—Afternoon shift inspection (during shift). "None except 2½ per cent. gas in No. 4 High Side off No. 4 Slope. Re-arranging ventilation tubes." These were both in the shuttle car section of workings.
During the period 28th June to 26th August there were eleven reports missing.

*8th October*—First shift inspection 12.15 p.m. to 1.15 p.m. "2½ per cent. of gas in Nos. 2 and 3 Rises (headings) caused through auxiliary out of order."

Back shift of same day, "2½ per cent. of gas in Nos. 2 and 3 Rises : auxiliary fan under repairs."

Later on same back shift timed 8.15 p.m. to 9.10 p.m. "Nos. 2 and 3 Rise clear. Fan repaired."

No inspection on behalf of the workmen had been made in this district during this period.

*Electrical Layout in No. 2 District.*—Plan No. 3 shows the arrangement of the electrical cables and apparatus in this district.

The apparatus was supplied by a 100 kva Transwitch Unit [(1) on plan] 3,300/550 volts, situated in a substation on the low side of No. 3 Level. The oil circuit breaker on the 550 volt side of the transformer was fitted with earth leakage protection and controlled the main cable passing up No. 3 heading.

This main cable passed through the busbars of a number of switches before dividing into several sub-circuits. No. 2 switch, at the foot of No. 3 heading controlled the main trunk belt conveyor in that heading and was operated by an adjacent push button. Nos. 6 and 7 switches, situated near No. 3 left third, controlled a Mono pump in No. 3 heading and No. 1 fan respectively. The main and tail haulage in No. 2 heading was supplied by a cable teed off from the main cable just on the inbye side of No. 7 switch.

The main cable terminated at two section switches, Nos. 10 and 11, a little below No. 4 right. No. 10 switch controlled the coalcutter and drilling machine in No. 5 right and No. 2 fan ; No. 11 switch controlled the two scraper chain conveyors feeding on to the No. 3 heading belt conveyor, one in No. 5 right and the other in No. 6 left, and the two duckbills in Nos. 2 and 3 headings. From No. 11 switch a pilot cable ran down No. 3 heading back to a push-button switch at the transfer point on No. 3 level, enabling the starting and stopping of the branch conveyors to be controlled, in relation to the movement of the main belt conveyor, from this point.

Just outbye of Nos. 10 and 11 switches a branch cable led further up No. 3 heading to supply No. 3 fan and the section switch, No. 19, controlling the supply to the coalcutters and drills in the headings.

The whole of the electrical apparatus in the district was of certified flameproof type, with the exception of the two shortwall cutters, two duckbills and the scraper chain conveyor in No. 5 right, which were of American design and manufacture.

The main and branch roadway cables were paper-insulated, lead-sheathed and double wire armoured, the short lengths of cable between the duckbills

and their gate end switches were pliable wire armoured, as were the conveyor pilot cables ; the coalcutter and fan cables were screened trailing cables, and the drill cables were unscreened.

A certified bell and approved dry battery were used on the bare wire signalling system associated with the 30 h.p. main and tail haulage, the bare wires extending inbye as far as the return wheel at No. 5 left, and outbye to the bottom of No. 2 supply road.

A similar dry battery signalling system was installed in No. 3 heading, the bare wires extending from the transfer point at the outbye end of the heading to about 20 yards inbye of No. 4 right, beyond which up to No. 6 left there was a pull wire by which signals could be transmitted outbye.

## II.—CONDITIONS LEADING UP TO THE EXPLOSION

Unfortunately all the men who entered the No. 2 District or Unit on the morning of the explosion were killed, and in the absence of direct evidence as to the work on which they were engaged it is necessary to consider first the situation which existed when the night deputy left the district some two hours earlier, the discussions as to procedure which ensued, and then to form conclusions based on evidence as to the position of the bodies and their injuries, the indications of force and other factors disclosed by subsequent investigations.

The sequence of events leading up to the accident was as follows :—

Coal getting operations in the district ceased with the termination of the day shift on Saturday, 7th December at about noon, the fans being stopped and all electrical power cut off.

At 10.30 p.m. on that day John Lewis Tubman, a shotfirer and spare fireman, descended the mine accompanied by a pumpman (William Urwin) who was left at No. 6 pump on the main plane. After calling at No. 3 district and starting a pump there and also an auxiliary fan, Tubman proceeded to the No. 2 district where he travelled up by the main conveyor road (No. 3 heading) until he reached the first auxiliary fan (No. 2) used for ventilating No. 4 heading. Testing the air at the fan and finding it clear and the tubes in order, he started the fan, after which he proceeded by way of No. 4 left thirl into No. 2 heading and back to No. 1 fan which was also started after making an examination in its vicinity. Retracing his steps to No. 3 heading and travelling inbye he reached No. 3 fan where he found the air clear and started the fan. This fan was situated between Nos. 4 and 5 left thirls, but he proceeded inbye a little beyond No. 5 thirl and found all in order. It would then be about 2.15 a.m. according to Tubman's estimate.

Some 15 minutes after the fans were started Tubman made an inspection at the face of both No. 2 and No. 3 headings and found no indication of firedamp. There was a canvas screen or brattice immediately over No. 3 fan extending across the whole width of the road but with a small opening covered by a loose sheet through which the belt conveyor passed, and according to Tubman a " good air " was being circulated. A canvas screen was also placed in No. 5 right thirl over the top of the scraper chain conveyor about three yards from No. 3 heading, beyond which a T-piece was provided in the ventilating tubes from No. 2 fan with extensions into the face of No. 4 heading and the fast end of No. 5 thirl.

Tubman came out of the district about 2.35 a.m. leaving the three fans running, and after visiting other parts of the mine to see that the pumps were working, reached the shaft and ascended about 5.35 a.m.

It should be stated that he had gone in on this shift to get the pumps and fans started because it was intended to move No. 3 fan forward on the Sunday morning.

Deputy John Proud Fisher descended at 6 o'clock on the Sunday morning accompanied by four men (including two maintenance engineers) for the purpose of moving forward the No. 3 fan, having seen Tubman in the pithead baths who told him how he had left things in No. 2 district. Fisher and his men proceeded together to the old shuttle car charging station where they left some of their clothing. All the three fans were then running, but on his way inbye to make an inspection, Fisher stopped first No. 1 fan and then No. 2 at about 7 a.m., the men following him inbye to No. 3 fan, a procedure not strictly in accordance with the requirements of Sect. 64 of the Coal Mines Act, 1911. He then inspected the face of Nos. 2 and 3 headings, testing for gas and, finding none, returned to No. 3 fan (which he said was situated a little below No. 5 left thirl) after having opened the door or flap (which was about 4 feet square) in the brattice screen over the conveyor belt to allow air to pass through to the face while the fan was stopped for moving up. Fisher disconnected the air tubes from the fan and left them suspended from the roof.

The fan was then pulled inbye for some 50 yards by means of a shortwall coal cutter (moved on the Saturday from No. 7 right thirl to No. 7 left thirl in readiness) the rope from which was extended by two short lengthening pieces to reach the fan, Glaister, one of the maintenance engineers, having first stopped the fan at the switch panel and then removed the plug from the fan socket. Having got the fan into its new position, where it stood on the floor, the trailing cable was dragged up to it, connected to the fan by Thomas Brown, the other maintenance engineer, and the switch having been put in at the switch panel by Glaister the fan re-started; the air tubes had been broken at a joint and re-attached to the fan.

It is necessary to explain that to start the fan two operations were required, first the closing of the isolating switch at the switch panel and then the operation of the push-button on the same switch panel. Some doubt was raised in regard to the efficiency of this push-button, the suggestion being made that it sometimes stuck—this point will be referred to later—but Fisher and Glaister affirmed that on this occasion it functioned without any trouble and the fan re-started at once and continued running satisfactorily.

About the time the fan had been got into its new position, Robert McCracken, who had been operating the coal cutting machine and was the man nearest to the face, remarked "I think it is getting 'dirty' up there"—meaning that there was gas or firedamp at the face. There was a flame safety lamp hung up about 10 yards on the inbye side of No. 7 thirling, which the deputy said he had been up to about five minutes before and had not noticed any indication of firedamp on it, though he knew "it was possible inbye that thirl to get dirty," and he did not bother about McCracken's remark as the fan was then ready to be re-started. This was about 11 a.m. the fan having been stopped over three hours.

After starting the fan, the brattice screen across No. 3 heading having been removed entirely so as to leave the road open, Fisher and his men came out to the charging station to have their bait. In about half an hour he returned to Nos. 2 and 3 headings and made a careful examination at the faces of each without finding any firedamp present. At that time the headings were being ventilated by an air tube in each, the fan was running normally, there was no fall or any movement of the roof to suggest the possibility of one at the junction of No. 2 heading and the No. 7 thirling, and after stopping the No. 3 fan he came outbye at about 11.55 a.m. While the fan was running the louvres were fully opened so that it would pass its full quantity of air, and it was left in this condition. Nos. 1 and 2 fans which had run during part of the shift were stopped after the men had taken their bait, and were not re-started.

Originally it had been intended to move up the switchgear controlling No. 3 fan, but owing to the difficulty of hauling up the fan—between the old and new positions of the fan the height of the roadway had been reduced by leaving down part of the bottom coal—and the time taken to effect this, it was decided to leave the switchgear in its old position, the length of spare trailing cable being sufficient to allow of this. The trailing cable therefore, as already stated, was pulled up by hand, and though no careful examination of it was made thereafter Glaister and Brown, who assisted with the work, said it was not damaged and they considered its condition satisfactory.

General Regulation 131 (c) requires that the electrician shall be responsible for the fulfilment of certain duties to be carried out by him or by a duly appointed assistant, among which are (ii) the examination and testing of all new apparatus and of all apparatus re-erected in a new position in the mine before it is put into service in the new position. It may be open to question whether such an examination and test was required in this case after the fan (not the switchgear) was moved up, but in my opinion it was. Reference will be made later to a piece of wire found after the explosion to be sticking out between the plug and socket attachment to the fan motor, evidently fitted to earth the pilot pin and complete the remote control circuit—the proper way would be to earth the pilot pin behind the plug socket to the framework of the motor or to use an interrupted pilot adaptor behind the socket, which latter method was in operation on some machines at this colliery. Glaister, who, as already stated, took out the plug before the fan was moved, and Brown who replaced it later both denied any knowledge of having seen such a wire, and said if they had seen it they would have taken it out ; neither of them however, claimed to have made a very careful examination of the apparatus and as stated no electrical tests were carried out after moving up.

Unless this wire was put in on the morning of the explosion (which seems unlikely) it must have been there when the fan was re-started after being moved forward, but apparently escaped the notice of the two maintenance engineers, both of whom were trained and regarded as assistant electricians.

Before leaving the district after the fan had been moved up Glaister put the isolator at No. 11 panel in neutral so cutting off all current from the duckbills and scraper conveyors. It was the practice, he said, to have this switch closed during the week, it being opened and the isolator put in " neutral " by the day shift deputy at the end of his shift on the Saturday, and so left until the Monday morning unless the maintenance engineers required the current for any purpose.

On the Sunday afternoon Robert O'Neill, a shotfirer, went down to attend to some pumps in other parts of the mine, but sometime between 2.30 and 3.30 p.m. he had occasion to go into No. 2 district to seek some grease near the scraper conveyor in No. 5 right thirl. He did not examine the place, nor. apart from getting the grease, interfere with anything in the district.

Alan Hannah, the night shift deputy (who had been a deputy only two months but had worked in No. 2 district previously), descended at 11 o'clock on the Sunday night accompanied by James Bateman, a pumpman. His duty was to see that the districts in the Main Band Seam were in order for the Monday morning shift entering.

They proceeded together as far as the first (known as the " back end ") pump in the main haulage road where Bateman was left to attend to the pump and Hannah continued inbye to No. 2 district, which he entered by way of No. 2 supply road or heading at about 12.15 a.m. (i.e., Monday morning).

Arriving at No. 1 fan he examined there and finding no gas went into No. 3 heading where the switch panel for this fan was situated and started it. He returned to the No. 1 fan and found it running satisfactorily, then returned to

No. 3 heading and reaching No. 2 fan started it up, the air there being clear. Continuing on up No. 3 heading at approximately the junction of No. 5 left thirl he " walked into an accumulation of gas." He had previously passed the switch controlling the No. 3 fan—he did not yet know the new position of the fan—but did not put it in because, as he said, " it is my job to make an inspection of the fan and the area around the fan to see that it is properly clear before starting the fan."

Asked what he then did Hannah said, " When I came across this accumulation of gas I was surprised and I think shocked to find such an accumulation. To shift it properly would have meant that I would have to have more men, and where I was going to get them from I did not know. In fact there was no way of getting men or assistance at that time. I decided I would do my best to shift this accumulation and that I would open the door in No. 5 left, and this I did." " This door," he said, " was about 6 feet high by 4 feet wide and was opened by fastening up the sheet which when closed hung down like a curtain. I then came down the belt road (No. 3), leaving the position as it was, and entering No. 1 district carried out my examinations and left that district clear."

After about an hour or an hour and a quarter he returned to No. 2 district and went to No. 5 left thirl which he found clear. " This " he said " proved to me that the intake and the return from No. 5 left was clear of any obstruction ; any obstruction I thought that was preventing the air from travelling up to the last (No. 7) thirl, was up in that area. I then decided that I would take the tubes from the No. 2 fan out of No. 5 right and put them straight up No. 3 heading." To do this he stopped No. 2 fan and then re-started it after fixing two lengths of tubing, i.e. 34 yards, up the No. 3 heading—the position of the fan was about 2 yards outbye of No. 4 left and the end of the tubes then some 10 yards beyond the entrance to No. 5 right. After transferring the tubes from No. 5 right thirl up the straight he opened the " door " of the canvas screen in that thirl to ventilate No. 4 heading. The velocity of air issuing from the tubes blowing up No. 3 was good ; there was a good draught through the door in No. 5 left and the air seemed to be going beyond No. 5 left and being drawn back through that door.

He said he tested the air outbye the end of the tubing in No. 3 heading by beating dust from his clothes and by breathing into the air to see if any re-circulation was taking place and there was none. He was satisfied the gas was not coming back on him but that the ventilation was taking its natural course, and then returned to Bateman at the pump to have his bait, leaving the No. 2 fan running. When he reached Bateman it was 3.5 a.m.

Bateman was an old and experienced pitman and Hannah discussed the position with him ; after having their bait they returned to No. 2 district together each having a flame safety lamp and a cap lamp. They went to No. 5 left thirl and found the gas had receded somewhat further up No. 3 heading. Going through No. 5 thirl Hannah went as far as No. 2 heading where in making a test for gas his light was extinguished by the gas, showing that beyond that thirl the No. 2 heading was also fouled.

Wishing to find out what the position was higher up Hannah, taking only his electric cap lamp, ran up to No. 6 left thirl (where there was a scraper chain conveyor) and opened the screen there. The canvas screen, he said, was opened in two halves, the first one on the prop on which the door was made by means of a five foot boring drill and the other side was jammed with a sleeper. On his way back he closed the screen in No. 5 left thirl, after having erected a fence at the junction of this thirl with No. 2 heading. He did not then test again for gas in No. 2 heading. In going up to No. 6 thirl Hannah passed the No. 3 fan in its new position, but there was no brattice sheet across the heading or other obstruction therein.

When he left the No. 3 heading there was gas down to about 20 yards inbye of No. 5 left thirl, but the impression he gained was that air was passing inbye beyond that point.

The door through the screen in No. 5 right thirl still remained open and was so left. Tests for firedamp in the No. 4 heading and the extension of No. 5 right thirl were made before and after removing the tubing from this thirl, but none was found.

As nothing more could then usefully be done in No. 3 heading Hannah proceeded outbye, through No. 3 left thirl into No. 1 heading, up this heading, leaving Bateman just inbye No. 1 fan and, following the course of the air tubes from No. 1 fan, went to near the end of the tube where he made an examination and found about one per cent. of gas of which, however, he took little notice as it was not uncommon to find a little there and he thought some gas would be coming from No. 2 heading. Although he did not then know that any one was to work there, he knew timber was being drawn out of these workings and that if men were to work in this section it would be at this place. This was where the brothers Bird were found after the explosion. It was about 4.30 a.m. when this examination was made, and he then proceeded outbye by No. 2 level to No. 4 district to make his pre-shift examination, leaving Bateman at No. 6 pump, and thence to the Lickbank Junction where he reported in the report book the accumulation of gas he had found in No. 2 district and that he had fenced the area off. Thereafter he proceeded to the shaft where he met the overman Hoodless in the undermanager's cabin and told him of the position. The undermanager then came in and he too was told of the position.

James Bateman gave confirmatory evidence of the conditions as found when he accompanied Hannah into the No. 2 district, except that he said that when the deputy first tested at the face of No. 4 heading his lamp, in Bateman's view, showed about one per cent. of gas present ; when he tested later, however, there was none to be seen.

Bateman further said that after the deputy had returned to him upon opening the screen in No. 6 left thirl they stayed some 15 minutes in the No. 3 heading during which the deputy made several tests for gas ; they formed the opinion that conditions were improving because, although Hannah went no further up the heading during that time, he was able to raise his light a bit higher in the roadway before finding the gas.

## III—NARRATIVE OF THE EXPLOSION

The morning shift on Monday, 9th December (the day of the explosion) descended at 5.30 a.m. It included 13 men and the deputy Miller who were to work in No. 2 district, and John McMullen, normally a stone worker but who was sent that morning to work at the transfer point at the entrance to No. 2 district, where the belt conveyor in No. 3 heading delivered its coal on to the main trunk belt. They were accompanied by the overman, William Hoodless.

The task confronting these men was to get the accumulation of firedamp cleared as quickly as possible so that normal coal getting operations proceed in Nos. 2 and 3 headings. Since the night shift deputy had reported No. 4 heading and No. 5 right thirl extension fit for work it was considered apparently that these could start at once, and the positions of three of the bodies indicates that they had either started or were about to do so. Two others were to be employed in withdrawing supports in the old shuttle car workings and here they were found.

Most of the others presumably were to assist in restoring the ventilation—the overman directing operations; the plan of action, as explained by the overman to Glaister, was to advance the air tubes from No. 2 fan until No. 3 fan was clear of gas and then to run the No. 3 fan. Evidence was also given by Glaister of seeing two bales of canvas being taken inbye and being told by John Fox (one of the deceased) that he and his mate Pflaumer were going to erect a canvas screen on the inbye side of the fan which had been moved up on the Sunday. The canvas bales would be taken up No. 2 heading to the return wheel, it was suggested, by means of the haulage engine in that road and then carried forward by hand.

J. W. Glaister, who had helped to move the fan up on the Sunday, went into the No. 2 district on the Monday morning to seek some tools he had left at the old charging station; he arrived there about 7 o'clock and left about 7.45 a.m. to go into No. 1 district in which he was to work.

When he left R. H. Brown the maintenance engineer in charge on that shift was still at the charging station.

Glaister said the main belt in No. 3 heading had not then been started as, if it had been running, he would have heard it from where he was at the charging station and also Brown would have proceeded at once to the heading. Nor was it running when he passed the transfer point and spoke to McMullen on his way to No. 1 district.

On the other hand, John McMullen, whose job it was to control the running of the No. 2 district belts and who although seriously injured by the explosion was able, fortunately, to give evidence at the Inquiry, said the main belt was running from about 7 o'clock almost continuously, though very little coal was being delivered by it at the transfer point—mostly in small intermittent patches of a few shovelsful as though of cleanings up.

He was actually engaged in cleaning up spillage (of which there was more than usual) at the transfer point, and so probably was not paying very great attention to the belt delivery.

Some minutes before the explosion occurred the deputy, Miller, came outbye to the transfer point. He asked McMullen what had been wrong with the belt, to which McMullen replied that the trunk belt on the main road had been standing. The belt, however, had then been re-started and was running. Miller then retraced his steps inbye along No. 3 heading, and had only proceeded about 15 yards when, as McMullen put it, "I knew no more."

McMullen was later found unconscious—he had been burned on the left side of the face, right hand and the left thigh, and badly shocked.

Glaister was working at a conveyor in No. 1 district about 600 yards from McMullen when the explosion occurred. He said it was like a heavy fall of stone and the blast which accompanied it flung him over the conveyor and threw stone dust from the sides into the air. It was followed by a smaller explosion, perhaps seconds after the first one.

Along with a mate working with him he came out to the transfer point of No. 1 district with the main trunk belt and tried to telephone but could not do so—the lines had been damaged. On No. 2 level he found the deputy who was going in to bring out his men, but the men were already on the way outbye. Together they all travelled out by No. 2 level, the usual travelling road, some distance and then through a thirl on to No. 3 level (the trunk belt road) and reached the transfer point of No. 2 district where they found the conveyor structure piled up in the roadway and other damage. It was not until later that McMullen was found here. From this point Glaister telephoned to the undermanager at the surface giving the alarm.

Thomas Barton, deputy in No. 4 district said the explosion sounded " like a big dull thud or the closing of a big door " and the auxiliary fan in his district stopped. He heard only one bump. He proceeded inbye, met some haulage boys coming out and then some men from No. 3 unit, and then passing the transfer point of No. 2 district where the air was thick with dust and smoke, was going into No. 1 district when he met men coming out and turned back with them. On the instructions, by telephone, of the undermanager he went to examine some of the airways but collapsed and was sent outbye.

*Rescue and Recovery Operations*—Rescue operations were set in motion without delay and everything possible done to penetrate the affected workings to render such help as might be of avail to any of the unfortunate men.

It was soon evident that the explosion had travelled outbye right to the transfer point on No. 3 road with considerable force, the air crossing (which was of substantial construction) having been demolished, doors and other ventilation arrangements destroyed, and numerous (and some heavy) falls had resulted. All this made the work difficult, and because of the wet conditions unpleasant, but no effort was spared by officials or workmen of this and other collieries to reach the entombed men. By 9.45 on the morning of the explosion the first trained rescue team from Brigham Central Rescue Station had arrived complete with equipment under the direction of the Superintendent, Mr. Charlton, and they were quickly followed by the brigades from other collieries in the coalfield, reserves standing by to undertake duty as needed. In all, twelve brigades took part in the operations.

A few men outside the No. 2 district who earlier had been slightly affected by afterdamp in the return were treated by the rescue teams, but unfortunately by the time those in the affected district could be reached they were dead, death in most cases having been instantaneous.

By the Tuesday night all the bodies had been located, except that of the deputy Miller—he was not then known to have come outbye just before the explosion took place—and his was found on the Saturday night, several falls having, in the meantime, been cleared in an effort to locate it.

Investigations by mines inspectors, colliery officials and others were pursued after the ventilation had been restored, further falls being cleared to examine electric apparatus and cables, some of which was brought to the surface for closer inspection.

The positions of the bodies, pieces of apparatus, falls, etc. were carefully noted, and these are shown on Plan No. 1. The direction of force as shown by the displacement of stoppings, apparatus and supports was also recorded. I personally made an inspection of the mine on 20th December accompanied by mines inspectors and officials of the colliery.

## IV—CAUSE OF THE EXPLOSION

The explosion was primarily one of firedamp. The deceased officials and workmen went into the district with the intention of clearing an accumulation reported by the nightshift deputy to exist in Nos. 2 and 3 headings and which he had only partially succeeded in moving, and it is reasonable to conclude that the explosion occurred while they were thus engaged. There was general agreement among the inspectors, management and Mr. Price (called as an expert by the owners) that the point of origin was within an area extending from half-way between No. 5 and No. 4 left thirl in No. 3 heading, outbye down to and including No. 4 left thirl and No. 5 right thirl, but excluding No. 2 heading. This suggested area was extended slightly as between one witness

and another, but that indicated was common ground, and I am myself satisfied the explosion originated somewhere in this vicinity.

The point at which an explosion commences frequently represents a quiescent spot with little or no evidence of force, the violence becoming evident as the explosion gathers momentum and is met by obstruction.

But while witnesses said where they considered the starting point was, and also the course which the explosion subsequently followed, no one felt able to express any definite opinion as to the cause of ignition. It therefore becomes necessary to examine the various possibilities. What then were the possible sources of ignition within the area described? They were :—electricity, shotfiring, electric cap lamps and flame safety lamps.

*Electricity*—Mr. Frederick Thomas Hindley, one of H.M. Electrical Inspectors of Mines who made a detailed examination of the electrical plant after the explosion, and Mr. Joseph Pattinson the chief electrician at the colliery who accompanied him on these examinations, both gave evidence of certain defects found to which reference must now be made.

(*a*) The first were in a bank of three panels, Nos. 13, 14 and 15 at No. 4 left thirl. Two of these panels controlled the No. 2 fan and the coal cutter in the chain conveyor area, and the third one, No. 15, controlled the drilling machine in the same area—No. 5 right. Nos. 13 and 14 were G.A.1 contactor panels and the bus-bar chambers communicated one with the other. No. 15 was a MU.10 drill unit and a bus-bar end plate formed the connection between panels 14 and 15. There was therefore a continuous bus-bar chamber for 13 and 14, but a barrier between that and No. 15 so that No. 15 can be left out of further account.

Examination showed that a loose incoming connection to the rear bus-bar in panel 13 had given rise, at some time, to considerable heating and arcing at this point ; solder from the cable lug had melted and splashed on the bottom of the chamber, and some fusion had occurred at the poor contact between the lug and bus-bar. Given sufficient load, or any vibration such as might be caused by the opening or closing of the contactor below, sparking would very probably occur at this faulty connection.

The outgoing 100 amp. B.S. socket on No. 14 panel had at some time been replaced by one of another make and, owing to the difference in the fixing centres, could only be attached by one set stud instead of four. This did not form a flameproof joint between the base of the socket and the socket adaptor, and provided a path from the 13 and 14 bus-bar chambers to the external atmosphere. The socket which had been attached to No. 14 was found some little distance from the panel, having apparently been blown off by the explosion. The top left hand corner had been badly bent as if the socket had been lifted upwards against the stud to which it was secured, and the flange of the adaptor was also slightly bent at the corresponding corner. When the socket was put back on the adaptor and bolted up with one bolt there was an opening at the lower end of the flange of almost a quarter of an inch.

These two panels were brought to the surface and sent to the S.M.R.B. Testing Station at Buxton for official testing, which was carried out in the presence of representatives of the various parties. The tests carried out and the results were thus described by Mr. Rainford :—

> The apparatus I received at the testing station, comprised two gate-end switch units coupled together such that the two bus-bar chambers formed a continuous chamber with a flit-plug mounting adaptor at one end and a blanking cover at the other end. Each unit was fitted with a marking plate

with the inscriptions Reyrolle-Hebburn, Type GA1/XI, the FLP. crown mark and the reference number FLP. 1406.

Q. Does that mean it was flameproof?

A. That means it was a certified flameproof design under that certified number.

THE WITNESS (*continuing*): The main enclosures were in accordance with the certified design except that the "start" and "stop" push buttons were inoperative. The double bus-bar chamber, formed by the two single chambers bolted together at a centre flanged joint, was in accordance with the certified design. The outgoing cable attachment at the rear of Item No. 13 bus-bar chamber, comprising an angle adaptor fitted with FLP. 1455 B.S. socket, was in accordance with the certified design. A similar angle adaptor was mounted at the rear of the No. 14 bus-bar chamber and that was in accordance with the certified design, but the adaptor was fitted with a B.S. plug socket marked FLP. 1319, the socket of which is not designed to suit the facing of the adaptor. With reference to that the difference between bolt centres of the adaptor and the socket base would permit of only one fixing bolt being used as received at the testing station. This socket had a flange which was bent outwards at one corner where the one fixing bolt was fitted, so that when the bolt was screwed home the socket canted to one side. This prevented the socket spigot from engaging fully with the bore of the adaptor facing and at one side the socket flange joint was also left open with a gap of a quarter inch approximately.

The last point recorded is that the removal of the top covers from the bus-bar chambers revealed a loose connection in Unit No. 13, between the outer bus-bar and the connecting lug on the end of one of the incoming cable tails, and there was evidence of heating and possibly sparking at this point.

We prepared the double bus-bar chamber for test as regards flameproof enclosure by drilling and tapping the top access covers for the purpose of introducing an inflammable mixture of firedamp and air and also for the purpose of applying an ignition plug. We made a series of three tests; no ignition of an external inflammable mixture was obtained with ignition of an internal inflammable mixture effected at a point adjacent to the faulty bus-bar connection referred to above, this ignition point being remote from the open socket joint referred to. The damaged socket component was then replaced by a new socket of the same design, secured by the one bolt as before. The ignition point inside the chamber was not altered, and no ignition of an external inflammable atmosphere was obtained in a further series of three tests. The original socket with the bent flange was then replaced, so as to reproduce the open flange joint as before, but the ignition point inside the chamber was transferred to the other end of the chamber adjacent to the adaptor on which the socket was mounted. Under these conditions of test, ignition of the external inflammable atmosphere was obtained on the first test applied.

That briefly covers the tests which were made.

Q. Those are tests made with the ignition point at No. 13 panel corresponding to where you found there had been certain evidence of flashing?

A. Yes.

Q. And the communicating point, if I may so put it, at the flange you referred to in No. 14 box. Now can you tell us what distance there would be between the point of ignition and the point at which communication could be made with the outside atmosphere?

A. Approximately 24 or 25 inches, that is through the double bus-bar chamber round through the elbow adaptor to the base of the socket.

Q. In other words you have a point of ignition in No. 13 box and the point of communication with the outside atmosphere in No. 14 box and the distance between those two points is roughly two feet ?

A. Yes. In other words the ignition point was remote from the opening.

Q. You made three tests, Mr. Rainford, and in no case did you get ignition ? You have had a lot of experience in tests of this kind. You would attach importance to the fact of this two feet distance between the igniting point and the communicating point of the outside atmosphere ?

A. It has been proved by experiment on a number of instances that ignition remote from an opening in such a way can reproduce conditions of flame propagation which would not allow flame to pass out of the opening.

Q. Only three tests were made, Mr. Rainford. Would you have expected if you had carried on for another three or six tests to have got an ignition ?

A. No. Those tests were based on a wide range of experiments and we are able to limit such tests to a few which impose the most severe conditions. We made the most incendive mixture of the internal and the most easily ignitable mixture for the external mixture.

Q. You yourself were quite satisfied that it was not possible to cause an explosion under these conditions of test ?

A. Under those conditions as reproduced for the test.

Q. Now you did, I think, carry out a test with the point of ignition a little closer to the opening ?

A. Yes, mainly for our own information. We have to take the opportunity of these circumstances to build up our own experience of data, and for this purpose we transferred the point of ignition from the remote end of the bus-bars to the other end of the bus-bars which are adjacent to the elbow adaptor. On the first test we obtained an ignition made under those conditions of the external atmosphere.

*By Mr. Harvey—*

Q. One of the first points you found in examining the apparatus was that the start and stop push-buttons were inoperative. Can you tell us for what reason ?

A. After we completed the tests we took off the main access covers and we found they were stuck in position by dirt.

Q. It was not that the electrical apparatus was inoperative ?

A. No, it was a mechanical defect of the push-buttons.

Q. Was that due to the explosion in your view or was it likely to be a condition that obtained before the explosion ?

A. From the condition of the push-button spindles I should say it was a condition before the explosion.

Q. You did in effect carry out six tests with the apparatus ?

A. Two series of three.

Q. The first three tests, I understand, were made with the apparatus in the condition in which it was found after the explosion, that applies both to the socket and the adaptor, the socket with the bent corner ?

A. I am working on information received at the time. I did not see the apparatus in the pit.

Q. In the first three tests the socket with the bent corner was used for that purpose in that bent condition ?

A. Yes.

Q. Is it not a fact the face flange of the adaptor was also slightly bent at that corner ?

A. It was slightly bent.

Q. And in the second three tests the new adaptor socket flange was flat and the adaptor flange was also flattened with the hammer before the tests were carried out ?

A. That is so.

Q. In your opinion were the conditions of the first three tests as likely to produce an explosion as you could make them in the circumstances ?

A. Yes, definitely.

*The defect thus disclosed is very disquieting and ought not to have existed, but on the result of the tests described, this panel cannot be held to be responsible for the explosion.*

(*b*) Another defect was discovered at the No. 3 fan. Here a piece of 26 s.w.g. wire was found looped round the base of the pilot terminal in the fan cable socket, with the ends brought out between the bore of the socket and the plug body. This wire formed part of the electrical interlock circuit, the proper connection between the pilot terminal and the motor casing having been omitted.

It was considered that if this wire were making only poor or intermittent contact, particularly if this was towards the outer end of the socket and the interlock circuit was not intrinsically safe, then any sparking between the wire and socket or plug might have been incendive.

This apparatus also was sent to Buxton and submitted to test with the result given in evidence by Mr. Henry Robinson, a Scientific Officer of the Safety in Mines Research Board :—

I received an Aerex fan, to which was coupled by belting a 10 h.p. induction motor made by Metropolitan Vickers. The motor name plate bore an inscription FLP103, Group 1, with the serial number of the motor. There was also a gate-end panel which was marked 18 in chalk, made by Reyrolle, Hebburn-on-Tyne. That carried the FLP certificate No. 1406 for Groups 1 and 2, together with the identification number A. 688. I also received one length of trailing cable complete with two plugs, one marked No. 2, which married with the socket on the 10 h.p. motor, and the other marked No. 1, which married with the socket on the gate-end panel.

I was informed by the Electrical Inspector that the electrical circuit had been completed in the pit by the use of a piece of 26's gauge wire, in a manner which has no doubt been described to you already. I therefore made my own connection in the same way and attempted to start up the fan by operating the push button on the gate-end box. I found that although the fan would start up it would only continue to run so long as that push button was kept depressed by hand. In order that the fan should run continuously that push button had to be kept spragged down by a wedge or some similar device. If pressure was removed from the push-button the fan stopped immediately, and throughout the whole of my tests I had to adopt that expedient in order to get the fan to run.

I opened up the gate-end panel to find out what was the cause of this defect and found that one of the leads which runs from the terminal of the push button to the No. 4 contactor was broken. The result was that, when the pilot circuit was completed and the contactors were closed, No. 4 contactor failed to short-circuit the push button switch, and hence as soon as the push button switch was released the circuit was broken and the motor stopped.

Q. Could you form any opinion as to whether that was a defect which had been continuing ?

A. No, none whatever. It was just a clean break in a piece of wire at a point where it is normally anchored underneath a terminal screw.

Q. And when that break was made of course you cannot say, nor form any opinion ?

A. No, sir it is quite impossible for me to say. Having got the equipment into a state where I could get the fan to run, I examined the fan first of all to see whether there were any signs of friction between the blades of the rotor and the casing of the fan. I found that the rotor ran smoothly in the casing without contacting the sides, and I observed the fan running for a long period in a dark room at its rated speed, and I could find no evidence of sparking caused by friction between the rotor and the casing. I did not proceed any further with that test. I was satisfied that if an ignition of gas had occurred it had not occurred as a result of frictional sparking.

I then proceeded to assemble the plug to the socket, using a piece of 26's gauge wire on a number of occasions. I found invariably that if I used a piece of new wire the motor ran perfectly and I could get no sparks whatever between the outbye end of that piece of wire and the earthed plug or socket, showing that a very good contact had been made. After each trial I stripped the plug from the socket, removed the piece of wire for examination and found that it had been flattened over the length where it was trapped between the plug and the socket. That is a length of about one and a half inches. It had been flattened from its original thickness of about eighteen thousandths variously down to sixteen thousandths and eleven thousandths, showing that the gap between the plug and the socket was something in the order of sixteen thousandths to eleven thousandths of an inch wide.

There was clear evidence on the surface of the wire of where it had been trapped, and I have no doubt whatever that a perfectly good contact was made providing that the wire was only used once. In the course of my trials I used one and the same piece of wire on four successive occasions and found that it became progressively thinned by being trapped, and eventually in its minimum thickness was only about eight thousandths of an inch.

I wished to try the effect of using a piece of dirty or oxidised wire, but not having any available I decided to use a piece of wire which was coated with enamel. I removed the enamel from that part of the wire which was anchored round the pilot pin in order to get a good contact there, and then brought the remainder of the wire out through the gap between the plug and the socket in the usual way, but the wire that I used was only twelve and a half thousandths of an inch thick ; that is to say, a thickness which was approximately the same as the thickness of the 26's gauge wire which had already been squeezed down in my earlier experiments. Under those conditions I found that it was not a difficult matter to dispose the plug in the socket in such a way that I could get any one of three separate effects. I could get a very good contact between the plug and socket and the wire mutually so that the motor ran quite normally, and I could not get any sparking whatever from the outbye end of the wire. On the other hand, sometimes I could get no contact at all. The motor would not then start up although the switches had been closed. Now under those conditions I could get sparking repeatedly from the outbye end of the wire, and with that sparking I ignited gas on quite a number of occasions. I could also get a third state of affairs where the wire was making only a poor contact between the plug and the socket. The contact was good enough to allow the pilot circuit to close the relays, and hence for the motor to run, but it was not good enough to keep the wire at earth potential, with the result that when I stroked the plug with the outbye end of that wire I could get sparks from it again—not so vivid as they were before, but even with those less vivid sparks, after continued trial I did succeed in igniting firedamp on four occasions.

The tests that I have described, sir, were carried out prior to a visit which was paid to the Research Station by Mr. Harvey and Mr. Young and the various other people, and on the occasion of their visit I attempted to repeat all these tests. The tests were all repeated in their presence, with the sole exception of the test where I attempted to get no contact, so that the motor would not start up; the tests under which, as I said, I could get repeated ignitions of gas.

Q. That is Test 2?

A. Yes. I was not able to repeat that in its entirety. I was able to dispose the plug in the socket in such a way that the motor would not start up, but as soon as I got hold of the outbye end of the wire to stroke it across the earthed plug the act of touching the wire completed the contact somewhere inside and started up the motor, so that I could not show that test in its entirety. What I did, however, was to demonstrate in this way, that by taking the plug out of the socket I was able to show that any sparks which could be drawn from the pilot circuit were certainty capable of igniting gas.

Mr. Hindley produced on that occasion the identical piece of wire which had been removed from the plug and socket assembly in the pit. That piece of wire I found to be extremely dirty, almost black with corrosion and oxidation, and in the state that it was, it approximated, I assert, to the enamelled wire that I was myself using. When that identical piece of wire was assembled again to the plug and socket the motor ran quite satisfactorily, but we could not get sparks from the outbye end of the wire when we stroked it against the earthed plug. The most that we could do, by moving the plug in the socket whilst the wire was in position and watching the contactors in the gate-end panel, was to notice that on three or four occasions those contactors came out, showing that the pilot circuit was being broken even with the piece of wire which was used in the pit, but I could not synchronise my attempts to stroke that wire across the earthed plug with the attempts which I was making at the same time, by moving the plug about, to break the circuit somewhere further up.

That, sir, is the extent of the tests which I carried out.

Q. Now with this actual wire which was later produced what condition would you have required to produce sparking?

A. You would require conditions under which the wire was not making a very good contact with the plug and socket, or was making no contact at all. Under either of those conditions you could draw sparks from the outbye end of the wire which are capable of igniting gas.

Q. You say you could draw sparks?

A. Yes, by bringing the wire into contact with an earth you would have got a shower of sparks.

Q. You have referred to the wire in your earlier tests being reduced in thickness by being trapped, and the progressive reduction increased the risk, I take it?

A. Yes.

Q. Had this wire you received, the actual piece of wire, been reduced?

A. Yes, I measured that in what appeared to me at the time to be about its thinnest place and it was down in thickness to about ten thousandths of an inch. That was its condition after it had been used again by me in my tests at Buxton.

Q. So that that would correspond in section to the worst condition which you produced in your tests?

A. Yes, I attempted to reproduce those conditions by choosing the right diameter of wire for my tests.

Q. And as you saw the actual wire and the condition of the apparatus what would be your opinion as to the possibility of that having ignited firedamp ?

A. Well sir, I should not put it higher than this, that there is a remote possibility that you could have the conditions all such at one and the same time as to make an ignition possible, but I would like to say that the chances of getting such an ignition are very considerably increased by the defect in the gate-end panel. If it were the fact in the pit that that gate-end panel had had to have its push-button switch kept depressed by means of a sprag, then any dangers which there might be in the pilot circuit are very vastly increased by the adoption of that practice. In fact, to do that is to throw away one of the most valuable safety precautions in that gate-end panel. May I go further, sir ?

Q. Yes, do. It is an important point and I want you to make it.

A. The point is this, that if that gate-end panel were in perfect working order and this push-button switch did not need to be depressed, then if you got a break in the pilot circuit, say at the motor end of the trailing cable, immediately you got a break there the push button switch would fly out, and from then onwards the whole of the line would be dead ; there would be no energy there.

Q. It would break the circuit ?

A. It would break the circuit completely. If, on the other hand, you kept the push-button switch on the panel held down permanently by means of a wedge or a sprag, then for every contact which you make at the remote end of the trailing cable, each contact will give its own electric spark. To go further, if therefore at the remote end of the trailing cable you imagine intermittent contacts, repeated contacts, if the gate-end box is in perfect order only the first one of those contacts will give a spark and the remainder will give no sparks, but if you have a push button switch spragged down every individual break will give its own spark, and that is why it very considerably increases the possibility of getting dangerous sparking.

Q. So the lesson to be learned from that is that push buttons should not be spragged in position ?

A. Most certainly.

They should work in their proper way, as they were intended to work.

*By Commissioner—*

Mr. Harvey, is there anything you would like to elucidate ?

*By Mr. Harvey—*

Q. Referring to this broken connection inside the gate-end box, bearing in mind the fact that the apparatus was conveyed from Harrington Colliery to the Testing Station at Buxton on a lorry under conditions of difficulty, over bad roads, do you consider that it is possible that the wire was broken away from the terminal in transit ?

A. I think it is a very definite possibility.

Q. I take it that you obtained the sparking between the wire in the plug by stroking the end of the wire against the earthed casing of the plug ?

A. That is so.

Q. Supposing the end of the wire had been in contact with the plug, could that have been reproduced by vibration of the fan during running ?

A. Yes, that is the most likely way in which it would occur underground.

Q. Always supposing that the fan was running at the time ?

A. Yes.

Glaister, it will be recalled, stated in evidence that when this fan was re-started after moving up on the Sunday the press button was in order and worked

satisfactorily, so it would appear that the broken connection inside the gate-end box was caused after that, most probably in getting the apparatus out of the pit and transporting it to Buxton.

On this evidence, therefore, it must be concluded that the possibility of the piece of wire between the plug and the socket used as an external earth having resulted in incendive sparking was very remote, though in certain circumstances the possibility could not altogether be dismissed.

It should be pointed out that the pilot circuit in this case was covered by a Buxton certificate of intrinsic safety, which in the light of the tests following the explosion may need to be revised.

There was a concensus of opinion among the technical witnesses that the fan could not have been running when the explosion took place and therefore could have no connection with it. This was based chiefly on the fact that two of the four belts used for driving the fan were found broken and lying in the fan casing. These had the appearance of having been cut or torn straight across by the fairing over the fan pulley which was dented in by the explosion, whereas, it was contended, if the fan had been running at the time the belts would have been cut longitudinally and would have been drawn into the blades of the fan. This was said to have happened previously when belts had broken.

Whilst in view of the clear evidence of the fan having been struck by a major force reaching it from some point outbye I was satisfied the explosion did not originate at it, it was important to know whether the fan was running or not, and, to clear up this point as far as possible, I considered it necessary to have a detailed examination of the fan and the belts carried out by a mechanical engineer ; this was done by Mr. A. E. Crook, H.M. Mechanical Engineering Inspector of Mines after the Inquiry was closed, and his report is given as Appendix III.

This shows conclusively that the fan was rotating at a considerable speed when the inlet fairing, severely damaged by the force of the explosion, was brought into contact with two of the driving belts causing them to break. Having regard to the magnitude of the force necessary to so damage the fairing —and also to bring about the other damage seen in the immediate vicinity of the fan—and the speed with which such a force must have travelled, it seems to me inconceivable that the one force—there was no evidence of any other—striking the fan should have (in sequence) started it from rest, accelerated rotation to a high speed and then driven in the fairing with great violence to fracture the belts.

*I am convinced that when the explosion occurred No. 3 fan was running in the normal manner.*

(*c*) There were three points at which cables were found to have sustained damage, and in each case the cable was opened up and carefully examined ; the conclusion reached in all was that the damage resulted from the explosion and had not been the cause of it ; moreover, none of these damaged parts was within the immediate area in which the explosion was deemed to have originated.

Owing to their being buried under falls it was not possible to examine minutely all the cables, but they were all tested for insulation and conductivity without any defects being revealed.

*My conclusion therefore is that the explosion was not caused by electricity.*

*Shot-firing—*

On the morning of the explosion the only person in the No. 2 district responsible for the charging and firing of shots was the deputy, Tom Miller.

He was issued by the colliery policeman and explosives keeper (Alfred Stephenson) with detonators in a locked tin—the key being kept by the deputy —but no record was kept of the actual number, the practice being to record the number at the end of the shift when the tin was returned and the number used was also ascertained. Stephenson said, however, that it was usual to issue 30 in the tins, which were filled up again at the end of the shift before re-issue, and that would be the number given to Miller.

As will be seen on Plan No. 1, after the explosion 22 detonators were found in No. 3 heading between Nos. 4 left and 5 right thirls—they were in two bundles of 10 each and two single. A tin was also found badly damaged with the lid severed, which it would seem had contained the detonators. If in fact Miller took 30 detonators into the district eight remain to be accounted for. It is possible some of them were set off by the explosion, or, as the manager suggested, they might be buried among dirt and debris which had not been cleared up.

The explosives were carried in by the men who were to use them and on the morning of 9th December, for the No. 2 district, one tin was issued to Hill and one to Chapman, each containing 5 lb. of Dynobel. Some four or five days after the explosion these tins were returned to the store. One remained full as issued, and a little (about a pound) had been used from the other.

In No. 4 heading some distance back from No. 5 right thirl a battery exploder was found with one lead attached ; it was the practice in the headings to use two leads, one on each side of the road, and the manager explained that they were usually left lying in that position. A powder tin was also found in this heading, but Stephenson could not state definitely whether it was this tin from which the explosive had been used.

There was some argument as to whether a shot had been fired at the face of the extension to No. 5 thirl out of this heading. Robert O'Neill, a shotfirer, stated that on the Saturday morning before the explosion he fired six shots in this place—one by Cardox and five by explosives—most of the coal from which was filled out on that shift before he left, but probably four or five tubs would remain. The shots were not good shots and some sockets were left on. After the explosion he had seen this place, and had formed the opinion there was " a bit " more coal lying than on the Saturday, from which together with the fact, as he said, that after firing on the Saturday he left the exploder near the corner of No. 5 thirl and the No. 3 heading, he concluded that one or more shots had been fired on the morning of the explosion. He brought his detonators out with him to the surface on the Saturday.

On the other hand evidence was called to show that on the morning of the explosion the conveyor in No. 3 heading did not run as long as McMullen had estimated, that very little coal came out of it, and that the presence of the sockets from shots and the general appearance of the face indicated that no further shot had been fired.

There was general agreement that if any shot was fired in this place on the morning of the explosion it would be by the deputy Miller, but there was no suggestion by anyone that even if this did happen it had anything to do with the explosion. The positions in which the deputy, and the three men Nos. 2, 5 and 6 were found clearly supports this view, and *I therefore conclude that shotfiring was not responsible for the explosion.*

*Electric Cap Lamps—*

The electric lamps in use were all Oldham-Wheat Type " Q " cap lamps ; some of the lamps were recovered complete and parts of others were found, and all were subsequently examined by Major Platt at the Mining Equipment Testing Station, Sheffield, who gave evidence on their condition as follows :—

I came to this conclusion, that a number of the lamps were in such a condition that they were not likely to have been the cause of any ignition in the mine. As regards other lamps which were incomplete—that is to say, the headpieces were missing, and those headpieces had apparently been wrenched away from the battery cable by force—whilst the batteries were in good condition, as also were the cables, I could not give any opinion as to the safety of the missing headpieces, and the doubt comes in as to the safety of those because I was unable to say whether those headpieces were in safe and good condition immediately before the explosion. If one of them had been smashed with respect to the protecting glass and the glass envelope of the lamp bulb, it is possible that gas might have been ignited by exposed incandescent filament. As regards the three smashed headpieces unaccompanied by any other part of the lamp, all three of those were badly smashed—I think it is quite fair to say, obviously by violence. Two of those headpieces had complete protecting glasses, but the glass envelope of the lamp bulbs was smashed, and it might be that the smashing of the envelopes of the lamp bulbs would have exposed the incandescent filament to gas, which would have entered the headpiece through the smashed moulding of the shell. I cannot say any further than that. As regards the third smashed headpiece—these are the three headpieces I received from Mr. Nussey subsequently—although the bakelite moulding of the shell was badly smashed, the protecting glass and the lamp bulb were both intact, and I suggest that that headpiece had no part to play in the ignition. I think that summarises what I found, sir.

*By Mr. Sandlands—*

Do not think I am raising this as a probable starter, but I want to eliminate it : It is a fact, is it not, that if the cable connecting the cap lamp to the battery carried by the miner is severed or broken, you might get a spark, which could ignite gas if the man was in it ?

A. It can be done under certain circumstances, yes.

Q. It is just a possibility ?

A. Yes.

Q. And it is also a fact that a cable which was perfectly sound on examination on the miner entering the Pit might get damaged in the course of his work ?

A. That is so.

Q. It is only just to show that it has not been overlooked. You do not think in this case it is really a serious thing that we need consider ?

A. No, certainly not.

Having regard to the area in which it was agreed the ignition occurred, only lamps numbered 139, 131, 156, 499, and 20 belonging respectively to Addison, Hill, Largue, Hoodless and Brown, need be considered.

The first three were in a complete state of assembly and were reported safe for use. Of No. 499 Major Platt reported that the cable sheathing was stripped back 4 or 5 inches from the gland on the headpiece, but this stripping of the sheathing played no part as a source of ignition ; otherwise the lamp was in safe condition.

The battery and cable of No. 20 lamp were in good condition, but the headpiece had been wrenched off. A headpiece which was thought to be that missing from this lamp was badly smashed, but the protecting glass and lamp bulb were still intact, and it was considered that this headpiece was not responsible for causing an ignition.

Although it is not possible to state with certainty that the lamp worn by R. Brown was undamaged before the explosion it would require some force to

wrench the headpiece from the cable, and there was no indication of anything having happened apart from the explosion to account for this.

*It seems to me most improbable, therefore, that the ignition originated from an electric cap lamp.*

*Flame Safety Lamps—*

There were three flame safety lamps in the district at the time of the explosion. One of these, No. 51 an ordinary type miner's lamp, was found intact, locked and in good order, near to the bodies of the brothers Bird in the old shuttle car workings, and on examination by Major C. B. Platt, Superintendent Testing Officer of the Sheffield Mining Equipment Testing Station, was found to be in safe working condition.

The other two were found in No. 4 left thirl in a damaged condition and dispatched as found to Major Platt who gave evidence as to his examination of them as follows :—

Two of the flame safety lamps were officials' type lamps fitted with self-contained internal re-lighters, and both of those lamps were received in pieces ; that is to say, they were not fully assembled. Lamp No. 2 was received with the bonnet and the gauzes detached from the lamp frame. The spirit vessel was in position and locked to the lamp frame. The fabric of the top of the outer gauze was dented and torn away, making that gauze unsafe, although the lamp would still be protected by an intact second gauze. With regard to the re-lighter of that lamp, the pyrophor bar, popularly called a flint, and the compression spring which presses the flint on to the friction wheel of the re-lighter mechanism, were both missing, although the small brass cap which holds those two components in the re-lighter mechanism was present and properly assembled in the re-lighter. All the other parts of the lamp were intact.

As regards lamp No. 17, all the parts of this lamp were received in good order and properly assembled, except that the spirit vessel was unlocked and received by me unscrewed and separated from the body of the lamp. The top surface of the spirit vessel, which is normally protected against dirt by the base of the lamp frame, was heavily coated with mine dust.

Lamps Nos. 2 and 17 were produced and inspected in court. As regards the latter Major Platt showed that the screw-thread was perfectly efficient, and said if the spirit vessel had been wrenched off by the explosion he would have expected the threads to be badly damaged and stripped, but they indicated no undue play or wear.

Questions were put to Major Platt as follows :—

*By Commissioner—*

Q. Major Platt, the effect of what you have told us is this : that so far as No. 2 lamp is concerned you are satisfied that the damage which you have described could have been caused by the explosion ?

A. As regards the removal of that bonnet, I think so ; possibly the damage to the outer gauze.

Q. Possibly the damage to the outer gauze ?

A. Yes.

Q. And even so, there was still one gauze left undamaged ?

A. That is so.

Q. And as regards No. 17, you say, I gather, quite definitely that it would not be possible to unscrew the oil vessel and expose a naked light to the outside atmosphere ?

A. That is so, yes.

*By Coroner—*

Q. What could have been the purpose of unscrewing this No. 17? Whoever did it, what could have been the purpose of it?

A. That lamp is fitted with an internal relighter which might not have been working efficiently. Cases have been known of lamps being opened with a view to adjusting the working of the internal relighter. It is a very unsafe thing to do, of course.

*By Commissioner—*

Q. If it were opened in the pit (we have not any evidence of that yet, of course, nor may we have), that might have been a possible reason for opening it?

A. It might have been.

Q. To adjust the relighter?

A. Yes, but that is a highly dangerous operation.

Q. Why?

A. Because when the spirit vessel is removed from the lamp the inside of the lamp is left wide open to the outer atmosphere, and the Pyrophor relighter can produce a spark which would light gas within the lamp and the flame would come out through the top, which is normally filled by the burner of the lamp.

Q. So that with the vessel unscrewed the relighter could be worked and produce a spark?

A. Exactly. For the Coroner's benefit, I may explain that the Pyrophor relighter is, in effect, exactly the same in principle as a cigarette lighter.

As regards No. 2 lamp (which belonged to the overman Hoodless) it seems to me reasonable to conclude that the damage occurred either some time before or resulted from the explosion, and that since its inner gauze was still in good condition it could not have been responsible for igniting firedamp in what must have been a more or less quiescent atmosphere. No. 17 lamp, however, presents a very different position which demands serious examination.

The oil vessel or well of this lamp was found detached from the rest of the lamp, the vessel being about mid-way along No. 4 thirl and the remainder at the junction of No. 3 heading with that thirl and near the body of Hoodless.

In a signed statement the Manager (Mr. Graham) asserts that at about 3 p.m. on the day following the explosion he was on one side of the brattice sheet erected across No. 4 left thirl about 10 feet from the side of No. 3 heading and Mr. Hughes (the Agent) was on the other side. "When I rejoined him he gave me the well part of a flamelamp and showed me where he had found it. I gave it to Joe Pattinson, Chief Electrical Engineer, who put it in his pocket and took it to the surface, where it was kept in the surveyor's office until it was dispatched to Sheffield. I marked on the master plan under the supervision of the surveyor the place in which Mr. Hughes told me he had found the part of the lamp. This part was the one subsequently identified as belonging to No. 17 lamp. Both parts of the lamp are in my possession and they are, in my opinion, in a similar state to that in which they were found, except that they have been cleaned."

Thomas Nicholson, an overman, who was captain of one of the Rescue teams, descended at about 9 p.m. on the night of the explosion to explore the No. 3 heading, the air of which they found very thick. In one of the left hand thirls he asserts about 5 or 6 feet round the corner he kicked a flame lamp top which he picked up, brought back into the heading and placed on the belt conveyor. Here it was subsequently seen by the undermanager and others and its position marked on the plan. Nicholson did not see the well part of the lamp.

From this I am satisfied beyond any doubt that the two parts of this lamp were found detached in the positions stated, and since the screw threads of the vessel were in perfect condition and the lamp could easily be re-assembled by screwing up the vessel (as was done in Court) the vessel must have been unscrewed and removed from the body of the lamp before the explosion.

The lamp belonged to the deputy Miller, who when the explosion occurred was some 300 yards away from it. Why he had gone outbye and why in doing so he had left his flame lamp behind it is not possible to say, though if his journey was to be restricted to the main conveyor road he would not, of course, be likely to need his flame lamp as he had an electric cap lamp. Moreover, the flame lamp would be more likely to be useful to the overman who was engaged in clearing gas from the headings inbye, particularly if Hoodless' lamp was out of order.

The manager and other witnesses spoke in the highest terms of the experience and personal qualities of the overman, deputy and the deceased workmen, and considered that none of them would be guilty of illegally opening a safety lamp in such circumstances. While appreciating this attitude of confidence in the integrity of these officials and workmen, the fact has to be faced that the lamp was opened by someone, and I think an explanation can be offered which, without condoning the offence, affords reasonable grounds for the action taken.

I do not for a moment suggest that Hoodless would knowingly open the lamp in the presence of firedamp ; but what was the position which confronted him ?

Three men (Nos. 8, 9 and 10 on plan) were working near No. 3 fan ; they were either in or on the fringe of an accumulation of firedamp and they had no means of ascertaining the condition of the air. It was suggested in evidence that these men were either engaged in erecting or had just erected a brattice sheet across No. 3 heading at the fan, and there could, of course, be no object in putting up such a brattice unless the fan was running or was about to be run. It was essential that Hoodless should know what was happening to the gas in that region, especially if, as I am satisfied was the case, the fan had been started.

If, as I think it reasonable to assume, No. 2 lamp was out of action—it might possibly have already been damaged or, if it had been extinguished it could not be relighted because of the missing pyrophor bar—he was left with No. 17 lamp borrowed from the deputy. He had possibly been up to these men to make a test with this lamp and had had the light extinguished and it failed to relight. To relight or examine it, or to get another lamp he would need to go a considerable distance outbye and waste valuable time. In his anxiety to get the ventilation restored and the headings restarted, why should he not take the lamp outbye to a spot he considered to be free from firedamp, and there examine it and carry out any necessary adjustment ? No. 4 left thirl would seem to him to be a proper place for this purpose, since it was close to No. 2 fan which was blowing fresh air up the No. 3 heading, and No. 5 right thirl was partially open allowing some fresh air to pass up the heading through the thirl and down the No. 4 return.

*Such were the circumstances in which I visualise the lamp being opened. After removing the oil vessel Hoodless was, I think, trying the relighter when it operated and ignited firedamp.* The medical evidence showed that he was burned but suffered no external injury from violence, the cause of death being lack of oxygen and carbon-monoxide poisoning.

*All the evidence points to there having been at this point an inflammable mixture which continued inbye up No. 3 heading, the percentage of firedamp in the air gradually increasing until somewhere in the region of No. 5 left thirl it reached explosive point and there exploded with great violence.* The No. 3 fan was

projected several yards inbye, the three men near suffered very serious multiple injuries, and the chain conveyor engine was thrown inbye and the pans doubled round the corner of the No. 6 left thirl. The explosive force passed through the No. 6 thirl into No. 2 heading and thence right and left. In its passage down No. 3 heading the flame entered No. 5 right thirl at the extension of which, or at the face of No. 4 heading, there was some augmentation of firedamp which caused victims 2, 5 and 6 to be severely burned without otherwise suffering serious physical injury.

How is the presence of firedamp in inflammable mixture so far down the No. 3 heading to be accounted for, having regard to the evidence of deputy Hannah as to the position when he left the district ? *The explanation, in my view, lies in the starting of No. 3 fan, and this I am convinced was the factor which the overman failed to take into account and by which he was deceived.* The capacity of this fan with the louvres full open (as Fisher stated they were when the fan was run in its new position after moving up on the Sunday) was 8,750 cubic feet per minute, but assuming the louvres were set at a slight angle and therefore not quite fully open the quantity capable of being circulated by the fan can be taken as about 8,000 cubic feet per minute. What was the quantity reaching this fan ?

According to the evidence of McGregor, the total quantity of air entering the district, as measured in No. 3 heading at the air crossing averaged less than 17,500 cubic feet per minute. This air passed up No. 3 heading to No. 2 left thirl when it split, part of it going through that thirl into No. 2 heading where No. 1 fan was situated and the remainder continuing up No. 3 heading.

The No. 1 fan was of the same type and size as No. 3, but was said to be operated normally with the louvres set from half to three-quarters open ; thus it would be taking not less than 5,000 cubic feet per minute. This split returned down No. 1 heading where there was a regulator set (according to McGregor) to an orifice of approximately 20 square feet. It is apparent from the ventilation plan (No. 2) that some air would pass direct into the return additional to that taken by the fan, and this I assume to be about 500 cubic feet per minute making in all 5,500 cubic feet per minute circulating in that split. The quantity going forward up No. 3 heading to No. 2 fan would therefore be no more than 12,000 cubic feet per minute.

No. 2 fan was capable of dealing with 5,000 cubic feet per minute. It will be recalled that when Hannah diverted the tubes for this fan from No. 5 right thirl to blow direct up No. 3 heading he opened the brattice sheet in that thirl (the opening being approximately 24 square feet), and the undermanager, deputy Hannah and other witnesses were agreed that with this opening—the regulator at the outbye end of No. 4 heading remained unchanged—the same quantity might be expected to return by No. 4 heading as would be circulated by the fan with the tubes in their normal position, i.e., 5,000 cubic feet per minute.

Thus the total quantity passing up No. 3 heading beyond No. 5 right thirl cannot have exceeded 7,000 cubic feet per minute even without allowing for leakages between the intake and return outbye of which there must have been some. The brattice sheet in No. 5 left thirl had been opened by Hannah in his early efforts to clear the accumulation of gas and later closed again after he had opened No. 6 left thirl, but it was probably not left very tight. In any event some leakage would occur here.

All this to my mind clearly establishes that the quantity of air reaching the No. 3 fan was insufficient for its requirements. What the actual deficiency was can only be surmised, but it is of interest to note the estimate which the undermanager gave in reply to Mr. W. E. Jones as the quantity reaching the fan as follows :—

Q. What amount of air would you consider would be passing along that road at that particular time? Have you any estimate of the quantity of the air that would be available for ventilating that roadway?

A. 6,000 or 7,000 cubic feet as near as I can say at that time.

Q. 6,000 or 7,000 cubic feet per minute at the time the cloth had been removed in 5's thirl?

A. No. 6 thirl.

Q. No, wait a bit. First of all, you have made provision for circuiting the air into 4's return?

A. Yes.

Q. To what extent would that reduce the quantity of air available for ventilating the straight?

A. It would not reduce it any.

Q. How do you come to that conclusion?

A. Because we had already got a blower fan at this point taking air from this main ventilation which was already going into No. 4 and there was no more ventilation going through that point than what there would be when the fan was blowing.

Q. Would the normal ventilation passing along 5's thirl into 4's return not be in excess of that blown into that particular area by the blower fan?

A. There would not be much variation in it; very little.

Q. And you come to the conclusion that normally, under ordinary circumstances when the blower fan was working you would have 6,000 or 7,000 cubic feet of air passing inbye up the straight?

A. Yes.

I consider even the lower estimate of 6,000 cubic feet per minute most probably erred on the excessive side, but *in any case the running of the fan was bound to result in re-circulation of the air.*

Mr. Graham placed the start of the " blast " in No. 3 heading just in beyond No. 5 left thirl and Mr. Hughes suspected the point of ignition to be between No. 4 left thirl and No. 5 left thirl, the force developing inbye (which agrees with my own view), but both went on to account for gas in this area by assuming that by some means (probably the falling down of the sheet unnoticed) No. 6 left thirl became blocked, and the No. 2 fan, the tubes from which they suggested had been extended up to or beyond that point, forced the gas back down No. 3 heading and fouled that road.

If the sheet in No. 6 left thirl was closed (as seems to me likely) the more reasonable explanation is that it was closed deliberately by Hoodless or his men when No. 3 fan was started. The effect of running that fan would then be to draw air charged with firedamp from the return (No. 2 heading) through No. 5 left thirl, and possibly to a lesser extent through No. 4 left thirl, into No. 3 heading (and also to force gas back from the face down that heading) so creating just the conditions to produce the results which were afterwards found.

That, I am satisfied, is what took place.

Incidentally Mr. Graham spoke to evidence of the explosion having passed from No. 3 heading not only through No. 6 left thirl but also " through No. 5 left thirl and thence down No. 2 heading to No. 4 left thirl where it was joined by violence, not excessive, which had come down No. 3 heading to that point and passed through No. 4 left thirl." The course of the explosion as thus described confirms my view that air containing gas was being circulated between No. 4 left thirl and the No. 3 fan.

Whether coal dust played any part at a later stage in the explosion it is very difficult to say. The workings at, and for some distance back from the face were definitely wet with water raining from the roof in places, but tended to

become drier, though still by no means dry, farther outbye. Mr. McGregor stated that he regularly tested the roadways to see whether there was any dust which could be dispersed by blowing upon but could find none, and therefore no samples were collected for analysis, and for this reason it appeared that no stone dust was applied.

Samples were collected by Mr. Nussey on 11th December, though admittedly it was not easy to obtain them, and two of these taken in No. 3 heading—one between the 2nd and 3rd left thirls, and the other between the air crossing and the first right thirl—on analysis gave only 37.5 and 40.3 per cent. respectively of incombustible matter.

From the No. 3 left thirl the explosion proceeded outbye chiefly by way of No. 2 heading, but to a lesser degree also down Nos. 1 and 3 headings until it reached No. 1 level at which point there was very considerable violence; the brickwork and door in No. 2 heading were blown out into No. 2 level, the air crossing at junction of No. 1 level and No. 3 heading was demolished, and the conveyor in No. 3 heading outbye of the air crossing was thrown about and badly damaged, the deputy's body being found in a mangled condition among the wreckage. There were also signs of fairly intensive heating at the outbye end of No. 3 heading and in Nos. 1 and 2 headings.

It would appear, therefore, that more gas was picked up at about No. 3 left thirl (probably from the old shuttle car workings), and to this I attribute most of the damage outbye, but I cannot with certainty rule out the possibility that along the lower part of No. 3 heading the explosion was extended by coal dust.

One witness said he heard what appeared to be two 'bangs,' the first much more pronounced than the second; if this be so, the first was probably the main explosion at the inbye end of No. 3 heading, and the second the demolition of the air crossing.

*Cause of the Accumulation of Firedamp—*

The Management claimed that the ventilation arrangements were adequate and the evidence showed that up to the Sunday prior to the explosion no trouble had been experienced. They contended that the accumulation in this instance was due to the fall at the junction of No. 2 heading and No. 7 left thirl having occurred some time on the Sunday previous to Hannah's inspection, and that the closing of this connection, preventing the through circulation of air between the two advance headings, accounted for the accumulation. Evidence was given that additional water was raining from the roof at this spot making the strata slippery and tender, and that during the previous week extra supports had been set to strengthen the roof. Richard Norman, an overman, deposed that after the explosion, about the middle of January, he was instructed to make a special examination of the place to find out when the fall occurred. On the left side on the coal above the original roof he found a spattering of what he termed 'slush,' and alongside this fall standing up towards the coal was a prop the top of which also was spattered with mud. On this prop he also saw evidence of coking. From these he concluded that the spattering was caused by the explosion, and that the fall therefore occurred before the explosion.

Mr. Price, who gave expert evidence for the owners, also said he had seen the spattering of mud—this was six or seven weeks after the explosion—and had reached the same conclusion.

On the other hand the undermanager saw this place on the Friday before the explosion; it was then in order and he had no reason to anticipate further trouble there. Deputy Fisher also said that when he left the district on the

Sunday morning there was no fall at this junction, and no movement suggesting that a fall was likely.

The first person to reach this junction after the explosion was Thomas Hodson, the captain of a rescue team from Risehow Colliery which descended the mine at 4 o'clock on the Tuesday morning. He described the fall as pyramid shaped, the centre of which was right in the centre of the junction and tapering away in all directions. There was a space 18 inches high over the fall, but as he and his men were wearing apparatus they increased this by another foot by clearing away some of the stones, and they were then able to go up to the face of No. 2 heading and also through into the return outbye of the thirl.

*By Commissioner—*

Q. Would you conclude that there was a reasonable space for ventilation to go over that fall and down back No. 2 heading ?

A. At 18 inches high, sir, and your roadways were 6 to 7 feet high, it would make the air sluggish.

Q. I agree, if you have a fall like that you have impeded your ventilation ; there is no question about that. Do you still think there would be space to allow a reasonable quantity of air to pass ?

A. There should be no gases collected on top of the fall. 18 inches should allow quite sufficient air to get through.

Mr. McCracken, the undermanager, saw this fall on the night shift of the Tuesday—several others had passed over it in the meantime—and although the height over it varied he agreed that at the time of its occurrence it would average about 18 inches, and that would not cause a complete blockage of the ventilation.

Even if the fall was a pre-explosion one, therefore, I am satisfied that it did not block the passage of air through No. 7 thirl, though it would reduce it.

It was further suggested by the Agent, and Mr. Price supported this, that the fall at this junction, consisting of about 3 feet of coal and 4 feet of stone, liberated firedamp which contributed to the accumulation. If this did occur it seems to indicate that the ventilation lacked any driving power to deal with it since at least part of the gas would be emitted into the return opposite to and on the outbye side of No. 7 thirl, which in any event would not be closed immediately and according to the evidence was not completely closed after the explosion.

*In my view the accumulation was due chiefly, if not entirely, to a natural emission from the seam in Nos. 2 and 3 headings which the ventilation was inadequate to meet when the auxiliary fans were standing.*

As stated on page 6 deputies had reported some accumulation on previous occasions when an auxiliary fan was stopped ; the undermanager also said he had found gas occasionally " when the ventilation was disrupted " though not recently, and other witnesses agreed that when the fans were stopped gas might be expected to accumulate. That it was not reported more often following a stoppage was due no doubt to the practice of the deputy in each case starting the fan when he reached it, and leaving it running some time before he made his inspection.

These headings were being advanced at the rate of nearly 10 yards per week and were of large sectional area with coal roof and floor as well as sides, all of which might be expected to increase the emission of firedamp. Their large area, commendable on other grounds, had also the effect of reducing the air velocity, and as this was insufficient to turn the anemometer the quantity of

air passing was not measured. Moreover, it is more difficult to prevent firedamp accumulating in rising headings than in dipping or level ones, and a greater impact of fresh air is necessary to move an accumulation. There was no sudden fall of barometric pressure to account for the accumulation.

*I cannot escape the conclusion that the ventilation had not kept pace with the rapid face advance, and that the point had been reached where the quantity of air reaching the face, sufficient in the past, was inadequate to meet present needs.*

While the No. 3 fan was kept running the air would be kept in motion and, on the evidence, appeared to be in order (though some re-circulation was probably taking place), but when the fan stopped the air became sluggish and unable to prevent an accumulation—the headings it will be noted were some 40 yards in advance of the last thirling. In such circumstances the fan should have been kept running continuously and not stopped for lengthy periods at week-ends. Moreover, steps should have been taken to increase the quantity of air in the general current in No. 3 heading reaching the fan, the capacity of which was unusually large. The likelihood of re-circulation would be increased by the moving up of the fan on the Sunday since there was only sheet in No. 5 left thirl.

If a fall did occur at No. 7 junction on the Sunday afternoon this would aggravate the position, but I feel sure the primary cause of the trouble was as stated above.

## V.—OBSERVATIONS AND RECOMMENDATIONS

As already stated the system of working in No. 2 district was Room and Pillar fully mechanised on American lines, entailing the use of a considerable quantity of electrically-driven machinery (with its switchgear and cables) for cutting, drilling, loading and conveying and for ventilation, all at or in close proximity to the coal face.

This system is now in use with satisfactory results as regards output at a number of collieries and is extending. With such a quantity and variety of electrical apparatus in use it is apparent, in seams liable to give off firedamp even though not regarded as " gassy " in the accepted sense, that there is need for special precautions to ensure safety.

I would call attention to a few of these, not that they are new but because they are of such vital importance as to require stressing and the urgent consideration of all concerned.

(1) *The first and over-riding essential is the provision and maintenance at all times of adequate ventilation.* The speed of advance made possible with this method of working necessitates the careful planning ahead of ventilation requirements, and systematic checking of the ventilation by properly trained and competent officials. The use of auxiliary fans does not decrease this obligation but rather accentuates it, as is shown in the present case.

Recommendations on the use of auxiliary fans were made in my Report* on the Manvers Main Colliery Explosion, Yorkshire, and the Harrington Explosion emphasises their importance.

One of the recommendations made in that report (page 26) has special significance in the present case, viz : " When a fan driven by electricity has been stopped for any length of time a careful inspection of the workings should be made before it is restarted ; if, however, gas is known to be likely to accumulate on stoppage the fan should be kept operating."

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*Cmd. 6688

It is to be regretted that this was not observed at Harrington.

In my view the practice of the deputy starting up the fan after examining only at the fan, itself and leaving it running for some time before inspecting the workings beyond is not satisfactory, since it may easily create a false impression as to the adequacy of the ventilation, as I believe it did in this instance. Moreover, under such an arrangement, it is an easy, and perhaps not unnatural step—particularly if the inspection station is any considerable distance outbye —for the deputy to allow his men to pass beyond the station before he has completed the inspection of the whole of his district, contrary to Section 63 of the Coal Mines Act, 1911.

The Coal Mines (Ventilation) General Regulations 1947, recently made by you, to come into force on the 1st August, 1947 put some of these recommendations into effect. I consider these Regulations are urgently needed and their full implementation should not be delayed.

(2) The electrical apparatus should not only be (as was the case here) of the highest standard and of certified flameproof type—or its equivalent where, and so long as, apparatus of American design and manufacture is in use—but *special and constant attention must be given to its maintenance in that condition.* This, of course, raises the question of supervision.

Unfortunately some weakness in this respect was revealed in the case under consideration, though in my view it had no bearing on the explosion.

A maintenance engineer with electrical training and regarded as an assistant electrician was present on each shift as a member of the regular crew, and they appeared to be competent men with considerable experience in the types of apparatus in use ; but they had not for some time been receiving the necessary supervision and assistance of the expert electrical staff, partly owing to illness of the chief electrician but mainly through shortage of staff.

Mr. Pattinson, the chief colliery electrician, had not himself visited the No. 2 district for over a month prior to the explosion, and his assistant, who went underground at least once a week, last visited the district on 6th November when he accompanied Mr. A. A. Miller, the chief electrical engineer for the Company's Cumberland collieries.

Mr. Pattinson's replies to my questions were as follows :—

Q. That was the 6th November ?

A. Yes, in place of me. From memory I think that would be his last visit as well into that district.

Q. Am I right in assuming then that most of the electrical supervision in this district was left to these maintenance engineers ?

A. There was a good deal of the supervision left entirely to those maintenance engineers, because I had every confidence that they were carrying out their duties perfectly.

Q. So I think it follows that a good deal—in fact, most of it—was left to the maintenance engineer. You say you had every confidence in them ?

A. I had every confidence in them.

Q. And possibly on that account you left more to them than you ought to have left ?

A. Yes, although all the little troubles that we did have when I was available were always fully discussed.

Q. Yes, I quite appreciate that when they were in trouble they sought your advice ?

A. They did.

Q. And you left a good deal to them ?

A. Yes.

Mr. Nimmo was asked by Mr. Stephenson whether he agreed that with this amount of electricity in use much more careful handling was needed than with the old method, and said he did. On the question of electrical supervision he said there was a general shortage of competent electricians for mines, and they had suffered with other collieries; if more men were available they certainly should be employed. *It is to be hoped that efforts will be made to recruit and train more electricians as soon as possible.*

In his remarks at the concluding stage of the Inquiry Mr. Stephenson, speaking on behalf of the National Union of Mineworkers as well as the Cumberland Miners' Association said "as an organisation we feel that now there is a good deal more of this power loading machinery going into the mines it is essential we should have more electrical inspectors on the Inspectorate" and he hoped the Ministry of Fuel and Power would consider the point. In 1943 the strength of the electrical inspectorate staff was increased by the addition of four Juniors, but in recent months three experienced members of the staff have resigned to take up other appointments, seriously depleting its ranks. These vacancies will, I hope, be filled as quickly as possible so as to restore the Inspectorate to its full establishment.

Although such Inspectors serve a very important and necessary purpose, the responsibility for the safe installation and daily upkeep of the electrical apparatus must of necessity rest upon the colliery staff who are in constant touch with the work being carried on.

(3) *One further point arises, viz:—the necessity for ensuring that electric cables and switchgear near the face cannot be made alive after a prolonged stoppage until the area in which they are situated has been examined by the deputy or other qualified official and he has certified it safe to do so.*

Under the system of remote control at Harrington it was possible in certain circumstances for the attendant in charge of the main belt at the transfer point outbye to switch current on to panels No. 11 and 19 and thereby to make alive switchgear and even to start scraper chain conveyors situated beyond the auxiliary fans controlling their ventilation.

Tribute was justly paid by all parties at the Inquiry to the excellent work done by the Rescue Brigades and numerous others who voluntarily gave their services in an endeavour—unfortunately of no avail—to rescue the victims of the disaster, and later to recover the bodies. These efforts were in accord with the well-known high traditions of mining men, and I gladly record thanks to all who thus served.

I have the honour to be, Sir,

Your obedient Servant,

J. R. FELTON.

# APPENDIX I

## LIST OF WITNESSES

| | NAME | OCCUPATION |
|---|---|---|
| 1. | John Steven Faulds .. | Pathologist, Cumberland Infirmary |
| 2. | Robert Wilson Gallantry .. | Surveyor |
| 3. | John Lewis Tubman .. | Shotfirer |
| 4. | John Proud Fisher .. .. | Deputy |
| 5. | Thomas Brown .. .. | Service Engineer |
| 6. | James William Glaister .. | Service Engineer |
| 7. | Robert O'Neill .. .. | Shotfirer |
| 8. | John McMullen .. .. | Stoneworker |
| 9. | Alan Hannah .. .. .. | Deputy |
| 10. | James Bateman .. .. | Pumpman |
| 11. | Thomas Barton .. .. | Deputy |
| 12. | Claude Bernard Meister Platt | Superintending Testing Officer |
| 13. | John McCracken .. .. | Undermanager |
| 14. | Isaac Dixon McGregor .. | Training Officer |
| 15. | John Charlton .. .. | Superintendent of Rescue Station |
| 16. | John William Forster .. | Captain, Rescue Team |
| 17. | Alfred Stephenson .. .. | Storeman |
| 18. | Edward Tinkler .. .. | Shotfirer |
| 19. | Joseph Pattinson .. .. | Chief Electrician |
| 20. | Frederick Thomas Hindley | H.M. Junior Electrical Inspector of Mines |
| 21. | Herbert Rainford .. .. | Testing Officer, Safety in Mines Research Board Testing Station |
| 22. | Henry Robinson .. .. | Scientific Officer, Safety in Mines Research Board |
| 23. | George Douglas Nussey .. | H.M. District Inspector of Mines |
| 24. | Thomas Hodgson .. .. | Captain, Rescue Team |
| 25. | Robert Shepherd .. .. | Shift Hand |
| 26. | Patrick McGuigan .. .. | Shift Hand |
| 27. | Richard Diamond Norman | Deputy |
| 28. | James Adam Nimmo .. | General Manager |
| 29. | Frank Graham .. .. | Manager |
| 30. | Theodore James Hughes .. | Agent |
| 31. | Alfred Alexander Millar .. | Area Chief Electrical Engineer |
| 32. | George Price .. .. .. | Consulting Mining Engineer |

# APPENDIX II

## PARTICULARS OF PERSONS KILLED AND INJURED

| | NAME | AGE | OCCUPATION |
|---|---|---|---|
| *Killed* | | | |
| 1. | William Hoodless .. .. | 41 | Overman |
| 2. | Thomas Addison .. .. | 44 | Face Worker |
| 3. | Robert Henry Brown .. | 31 | Service Engineer |
| 4. | Charles Sharpe .. .. | 26 | Face Worker |
| 5. | John Tolson Hill .. .. | 39 | Face Worker |
| 6. | Daniel Largue .. .. | 43 | Face Worker |
| 7. | William Henry Ennis .. | 54 | Face Worker |
| 8. | Harrison Fidler .. .. | 37 | Demonstrator to Face Workers |
| 9. | Ronald Pflaumer .. .. | 32 | Bricklayer |
| 10. | John Fox .. .. .. | 34 | Bricklayer |
| 11. | Wilfred Chapman .. .. | 42 | Face Worker |
| 12. | Robert Maurice Bruney .. | 44 | Face Worker |
| 13. | John Wright Bird .. .. | 46 | Timber Drawer |
| 14. | Thomas Bird .. .. | 31 | Timber Drawer |
| 15. | Thomas Austel Miller .. | 41 | Deputy |
| *Injured* | | | |
| 1. | John McMullen .. .. | 54 | Stoneworker |

# APPENDIX III

## EXAMINATION OF NO. 3 AEREX FAN

Subsequent to the joint inquest and inquiry into the causes and circumstances of the explosion which occurred at the Harrington No. 10 Mine on 9th December, 1946, the Commissioner, Sir John Felton, asked me to make a detailed examination of the above fan and the two broken belts, and consider whether the fan was running or stopped when the explosion occurred.

I examined the fan at the S.M.R.B. Station, Buxton, on 14th, 19th and 20th March, 1947, with the following results :—

(1) This 478 mm./18.8 ins. DIA/11/M.P. Aerex Fan made by Walker Bros. (Wigan) Ltd., is fitted with a 3.5 ins. diameter pulley having grooves for six V-belts. The pulley is enclosed by a steel inlet fairing which is cut away on one side so that normally there is sufficient clearance for a drive of six V-belts from a 5.1 in. diameter pulley fitted to a 10 h.p. electrically driven motor.

Although provision had been made for six V-belts, the pulleys contained only two belts in the second and third grooves respectively. (No. 1 groove is nearest to the fan, i.e. on the right-hand side of Plate 1.) But as two broken belts had been found in the bottom of the fan inlet after the explosion, it would appear that there were four belts on the pulleys prior to the explosion, and that these belts occupied Nos. 2, 3, 4 and 5 grooves (this was confirmed on 9th April, 1947 by Messrs. Millar and Pattinson, who said that the drive consisted of four belts in the above grooves).

Each of the four belts was of the same type (A.60) and had been supplied by F. Wigglesworth. The lengths of the two broken belts were 5 feet $0\frac{3}{4}$ inches and 5 feet $1\frac{3}{8}$ inches, whereas the lengths of the two unbroken belts were 5 feet $2\frac{1}{8}$ inches and 5 feet $2\frac{3}{8}$ inches. The former belts were much darker in colour than the latter and may not have been out of the same batch or put on at the same time.

PLATE 1. View of part of damaged fairing, fan pulley and the two belts in Nos. 2 and 3 grooves.

PLATE 2. View of ends of the two broken belts which occupied Nos. 4 and 5 grooves prior to the explosion.

(2) The steel inlet fairing had been so damaged and displaced that it did not provide sufficient clearance for a drive of six V-belts ; Plate 3 shows that it was impossible to put belts in the sixth and fifth grooves. It was possible to put a belt in the fourth groove, as shown in Plate 4, and it will be noted that the fairing is touching and slightly deflecting the belt, but this did not prevent the fan from being run with a slight scraping noise. Although I feel it was improbable, but not entirely impossible, for the damaged fairing to cut the belt in the fifth groove if the fan was stopped, I consider Plate 4 shows quite conclusively that it was impossible for the fairing to cut or cause the belt in the fourth groove to be broken if the fan was stopped.

In my opinion the two belts in the fifth and fourth grooves respectively were broken when the fairing was damaged and forced inwards while the fan was rotating at a speed sufficiently high to induce an excessive pull in the belts at the instant they were subject to interference and nipping on the slack side.

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