MINISTRY OF FUEL AND POWER

ACCIDENT AT CRESWELL COLLIERY, DERBYSHIRE

REPORT

On the causes of, and the circumstances attending, the accident which occurred at Creswell Colliery, Derbyshire, on the 26th September, 1950

BY

SIR ANDREW BRYAN, D.Sc., F.R.S.E.

Presented by the Minister of Fuel and Power to Parliament by Command of Her Majesty
June, 1952

LONDON
HER MAJESTY'S STATIONERY OFFICE
1952

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The Right Honourable Geoffrey
Minister of Fuel and Power.

24th April, 1952.

SIR,

I.—INTRODUCTORY

In compliance with the direction of your predecessor, I have held a Formal Investigation under the provisions of Section 83 of the Coal Mines Act, 1911, and under the Ministry of Fuel and Power Act, 1945, into the causes of, and circumstances attending, the accident which occurred at Creswell Colliery, Derbyshire, on 26th September, 1950, resulting in the loss of 80 lives.

The accident was due to a disastrous fire which started at a transfer point of the trunk belt conveyor system in the South-Western Main Intake Haulage Road in the High Hazel seam. Because of the intensity and extent of the fire and of the inability to get it under control, it was found necessary to seal off the part of the mine in which the fire was located in order to extinguish the fire by depriving it of air. Not until the district was reopened about one year later, were investigators able to study fully the origin and extent of the fire and the probable course of events inbye where the victims had been at work, and so the Inquiry had to be held in two stages.

I opened the Inquiry at the Miners' Institute, Creswell, on the 17th October, 1950, and, after hearing evidence from 26 witnesses about conditions and happenings up to the time when the fire was sealed off, I adjourned the Inquiry two days later. It was resumed on the 27th November, 1951, when eight new witnesses were called and four of the previous witnesses were re-examined. The Inquiry concluded on the following day.

The appearances at the Inquiry were as follows:—

(*a*) *Ministry of Fuel and Power*
Mr. W. B. Brown, H.M. Divisonal Inspector of Mines
Mr. W. Widdas, H.M. Senior District Inspector of Mines
Mr. W. Whitehouse, H.M. District Inspector of Mines

(*b*) *National Coal Board*
Mr. W. L. Miron, O.B.E.
Mr. W. H. Sansom, M.C., Production Director
Mr. W. V. Sheppard, Area General Manager, No. 1 Area
Mr. J. Brass, Area Production Manager, No. 1 Area

(*c*) *National Union of Mineworkers*
Mr. S. Watson, C.B.E., and Mr. E. Jones, C.B.E.

(*d*) *Nottingham Area of National Union of Mineworkers*
Ald. W. Bayliss, C.B.E., and Mr. Bernard Hazelby

(*e*) *National Association of Colliery Managers*
Professor I. C. F. Statham and Mr. W. Sharpe

(*f*) *British Association of Colliery Management*
Mr. G. P. Thompson

(g) *National Association of Colliery Overmen, Deputies and Shot Firers*
Mr. B. Walsh, Mr. R. Walker and Mr. George Cooper

(h) *Association of Mining Electrical and Mechanical Engineers*
Mr. T. H. Williams

(i) *Safety in Mines Research Establishment, Ministry of Fuel and Power*
Mr. A. H. A. Wynn and Dr. W. C. F. Shepherd

(j) *Bolsover Colliery Company Limited, and The Midland Counties Colliery Owners' Association*
Mr. F. H. Jessop

A list of the persons killed is given in Appendix I. and a list of the 33 witnesses examined during the course of the Inquiry is given in Appendix II.

II.—PARTICULARS OF THE COLLIERY AND ITS BACKGROUND

(a) General

Creswell Colliery, formerly owned by the Bolsover Colliery Company Limited, was taken over by the National Coal Board in 1947. It is included in the No. 4 Sub-Area of No. 1 Area of the East Midlands Division, and is situated in Derbyshire near the Nottinghamshire border and lies about six miles south-west of Worksop.

The mine was under the daily supervision of Mr. G. Inverarity who, after a spell as a spare manager under the Bolsover Colliery Company, was appointed manager of Creswell Colliery in November, 1946. Mr. G. S. W. Payton, after a period as Safety Officer, was appointed undermanager in January, 1948. To assist them they had six overmen, a safety officer, a training officer and a number of deputies and shot firers. Above the manager was an Agent, Mr. J. A. Tankard, who, in turn, came under the direction of the Sub-Area manager for No. 4 Sub-Area of No. 1 Area, Mr. W. E. S. Peach. The No. 1 Area Production Manager was Mr. J. Brass, the Area General Manager was Mr. W. V. Sheppard, and Mr. W. H. Sansom was the Divisional Production Director. All of these higher officials from the undermanager upwards hold First-Class Certificates of Competency under the Coal Mines Act, 1911.

The mine has two circular shafts, each 18 feet in diameter and completed in 1896, which were sunk to work the Top Hard seam at a depth of 444¼ yards. The High Hazel seam was intersected by the shafts at 329 yards from the surface. In 1939, for exploratory reasons, the upcast (or No. 2) shaft was sunk to the Low Main seam at a depth of 736 yards. A cross-measure drift was then driven from the Top Hard seam to the Low Main seam and a connection was made with No. 2 shaft. In 1933 a cross-measure drift was driven at 1 in 3 from the Top Hard up to the High Hazel seam to enable faces in this seam to be opened out. Output from the High Hazel seam was gradually increased to replace the declining output from the Top Hard seam. Work ceased in the Top Hard in 1941, and, thereafter, all the output came from the High Hazel, so that at the time of the accident an extensive area of this seam had been worked out.

The High Hazel seam has an average inclination of 1 in 30, is about 4 feet 6 inches thick, and was worked by advancing longwall methods in three main producing districts, known as the North-West, South-East and South-West

Districts. There were 1,144 men employed underground and 355 on the surface. During the three months prior to the fire, the weekly was just over 14,000 tons, about half of which came from the South-West District. The coal from all three districts was transported to the pit bottom by trunk-belt conveyors and wound at the downcast shaft. Coal filling and winding were done on the day and afternoon shifts. Repair and maintenance work was done on all three shifts, but mostly on the night-shift. The general sequence of work on the coal faces was : cut, fill, pack and turnover.

Since the South-West District was the district directly concerned with the fire, it is the only one about which details need be given.

(*b*) *Method of Working*

The general lay-out of this district is shown in Plan No. 1. There were two main roads serving the district, the Main Intake, which was used for the transport of coal in trunk-belt conveyors, and the Main Return, which was used for the transport of men by an endless-rope haulage man-riding set. These two main roads were 60 yards apart for 1¼ miles from the pit bottom and 34 yards apart for the remaining 1¼ miles. A little more than half-way inbye, a downthrow fault—known as the Elmton Fault—was encountered. Originally, the South-West District was laid out to work coal only as far as this fault, but in 1945, it was decided to work coal beyond this fault. Consequently, in that year, two dip drifts, the intake dipping 1 in 9 and the return dipping at 1 in 6, were driven through the fault, which at this point is in the form of a trough, the first throw being downwards with 195 feet displacement, followed by an upthrow of 85 feet, making a total downthrow displacement of 110 feet.

Apart from 57's heading, which was winning out a new face not far inbye from the shafts, there were five double-unit faces in the district. Of these, No. 59's—the only one on the outbye side of the Elmton Fault—was a double-unit face, 295 yards long, where the seam was undercut by machine to a depth of 4 feet 6 inches in a dirt-band one foot above the floor. The coal was shot down by explosives and hand-filled on to conveyors. It was regarded as a standbye-face and was only worked as required.

Beyond the Elmton Fault there were four working faces and an abandoned face, No. 63's, which had been stopped when it reached an unproved fault at a distance of 840 yards to the right, off the main intake. Materials had been drawn off from this panel except for the supports in the right-side gate and the central-loading gate. The four working faces were known as the 74's, 64's, 68's and 65's respectively. Particulars of these faces are as follows :—

The 74's face was 167 yards long and formed the development panel for the area. Four gateways were formed in this development to provide two intake and two return airways. The working face was 2½ miles from the pit bottom. No. 64's was a double-unit face, 300 yards long, which had advanced 1,000 yards to the left off the main intake. The 68's face was 450 yards long but only two-thirds of its length was in production. This part of the face had advanced 410 yards to the left off the main intake, whilst the remaining one-third of the face, which had been stopped, had advanced 450 yards. No. 65's was a double-unit face, 330 yards long, which had advanced 300 yards to the left off the main intake.

With the exception of No. 68's, the working faces were machine cut at floor level to a depth of 4 feet 6 inches, the coal being shot down and hand-filled on to face conveyors. The production part of 68's face was worked by a Meco-Moore cutter-loader which took off coal to a depth of 3 feet 3 inches along the face and loaded it on to a face conveyor. Coal from the face conveyors in all faces was transported by gate conveyors to the main trunk conveyor system on the South-

West District main-intake road. Steel props and bars were used throughout on these faces and the three-props-per bar system was in general use. The normal thickness of seam on these faces was 4 feet, but from 5 to 6 inches of top coal was left up to form the immediate roof.

Prior to 1948, under-tub endless-rope haulage had been in use for transporting coal to the pit bottom along the main haulage road but in July, 1948, a complete change-over was made to trunk-belt conveying to a central loading point 90 yards from the pit bottom. The belts were of 7-ply construction with rubber facings. At the time of the accident this main trunk-conveyor system comprised three conveyors in tandem : No. 1 belt, from the No. 1 transfer point near the pit bottom to the No. 2 transfer point, a distance of 1,703 yards : No. 2 belt, from the No. 2 transfer to No. 3 transfer point, a distance of 1,080 yards ; and No. 3 belt, from No. 3 transfer for a distance of 1,060 yards to the point where the gate-belt conveyor from 74's face delivered its coal. With the exception of the coal from 59's face which was delivered on to the No. 1 belt at a point 69 yards outbye the No. 2 transfer point, the coal from all other faces was fed on to the No. 3 belt. These three main belts were each 36 inches wide and were each driven by 100 h.p. Sutcliffe Goliath Units. The belt speed was about 350 feet per minute. Each transfer point was covered in by a sheet metal canopy and water sprays were fitted for dust suppression. The roadway throughout was of ample cross-section and an endless-rope haulage was installed along one side of the conveyors for the transport of supplies. On the outbye side of the Elmton Fault, the roadway was supported by steel arches, camber girders and straight girders, but on the inbye side of the fault, steel arches were used as standard practice.

The complement of workmen in the South-West District on the three shifts was : day-shift, 93 ; afternoon-shift, 163 ; and night-shift, 122. On the night-shift of the 25th/26th September, however, because of transference of workmen from the South-East District, 133 persons were employed in the South-West District.

(c) Ventilation

The general direction of the ventilation, the air splits and the quantities passing at various points as recorded in the air-measurement book for the month of August, 1950, are shown in Plan No. 1.

About 60,000 cubic feet of air per minute entered the main South-West intake and trunk-conveyor road. Approximately one mile inbye, a split was taken off to ventilate 59's panel, leaving 44,000 cubic feet of air per minute to pass on down the intake drift through the Elmton Fault. Thereafter, other splits were taken off to ventilate, on the left side, 64's and 68's panels, and on the right side, 65's. The remainder of the air went forward to ventilate 74's development face. All faces were on unit ventilation. Safety lamps were used throughout.

(d) Fire-Fighting Arrangements

The measures, both in men and materials, for fighting fires on the surface or in the underground workings were well organized and, as will be seen from Plan No. 1, the facilities provided in the South-West District appeared to be ample to cope with any emergency. Fire-fighting water ranges were laid along the main-intake airways from the shafts to points near each working face. Hydrants were installed at intervals of approximately 250 yards and, in addition, at points such as gear-heads, junctions and transfer points. The pipes were usually 2 inches diameter, but a start had been made to replace those in the North-West District with pipes of 2½ inches diameter. Recent additions to the ranges in the South-West District were all this size, but preparations were also in progress to renew the South-West pipe range from the shafts with 3 inches-diameter pipes. Water was supplied from the 5 inches rising-main in the down-cast shaft which served as the pump range from the Top Hard seam. The pump in this seam was run only during the night-shift and arrangements were therefore made to feed water into the main from surface tanks during the day and after-noon shifts. In addition, another 1 inch diameter pipe was also used to supply water via the upcast shaft into the fire-fighting mains. This supply was kept running continuously and was generally sufficient to feed all the dust suppression water sprays. Reducing valves were fitted at each shaft bottom to regulate the pressure in the mains.

Fire stations were arranged at points along the main road. Plan No. 1 shows the standard equipment at each station. Manual force pumps were not kept at each fire station but one could quickly be transported from the shaft bottom. The equipment was examined and reported on monthly. Rules were laid down for the organization and conduct of fire-fighting work and fire drills were carried out regularly. The water pressure at the shaft bottom was between 400 and 430 lb. per square inch. Flow tests were made periodically and the last test made in June, 1950, at 59's hydrant gave a flow of 45 gallons per minute at a flow pressure of 20 lb. per square inch.

(e) *Man-riding Trains*

Arrangements were made for the mechanical transport of men to and from their work in the South-West District. These consisted of two man-riding trains operated in the main-return airway by an under-tub endless-rope reversible haulage, known locally as the " Paddy." The two trains were attached to the rope—one at the outbye end of the haulage and the other at the inbye end—so that when the haulage was running one train travelled inbye while the other travelled outbye. A three-rail track was used with a length of double track at the " meetings," situated between 400 and 500 yards outbye from the top of the Elmton Drift.

(*f*) *Telephones*

Telephones were installed at the following places to serve the South-West District:

(1) 59's junction, serving No. 2 transfer point and 59's face, which was 330 yards distant.

(2) No. 3 transfer point.

(3) 64's loader gate junction.

(4) Main road near 65's loader gate, serving 65's face which was 350 yards distant.

(5) 68's junction, serving 68's face which was 360 yards distant.

(6) 74's transfer point at the end of the main-trunk conveyor system, serving 74's face which was 425 yards distant.

(7) 64's tandem in the loader gate, serving 64's face which was 410 yards distant.

(8) Passbye or " meetings " on the man-haulage in the main-return airway.

(9) Inbye terminus of man-haulage in the main-return airway.

(10) Foot of Elmton Drift, main-return airway.

The main underground telephone system was controlled from a switchboard in an office situated in the main-return airway near the bottom of the upcast shaft. One attendant was employed at this switchboard on each shift on which persons were employed underground. On the day and afternoon shifts, the two coal-drawing shifts, there was usually a number of persons working within speaking distance of the telephone exchange, so that if the attendant received a telephone message which had to be given to someone near the pit bottom or which required some action in the vicinity, such as the tripping of a near-by electric switch, the attendant could call to someone to deliver the message or take the necessary action, without himself leaving his office. If, on the other hand, any such message was received on the night-shift, the attendant would normally have to leave his switchboard for a short time to deliver or act upon the message, because few persons worked within speaking distance of the exchange on this shift. This was a matter of little importance in ordinary circumstances but, as will be seen, it was of importance on the morning of the fire.

III.—THE FIRE

All parties agreed that the fire started at the No. 2 transfer point about 3.45 a.m. on the 26th September, 1950, when 232 persons were underground, of whom 133 were employed in the South-West District beyond the scene of the fire. Shortly before the fire started, however, two workmen had left the district, thus leaving 131 persons inbye at the time. Of these, 51 persons escaped by way of the return airway. The remaining 80 persons were
lost their lives. They were later certified as having died from carbon monoxide poisoning.

During the day-shift of the 25th September, it was observed that No. 2 trunk belt was scored. At the beginning of the afternoon-shift that day, J. R. Hindley, a belt-maintenance man, was called to examine it. He found a groove, about 6 inches from the belt edge on the supplies track side, extending along the belt for a distance of nearly 300 yards. In no place was the belt cut through but for a short length the groove had penetrated about two-thirds of the thickness of the belt. Along with others, Hindley examined the conveyor throughout its length but nothing was found that would account for the grooving. The conveyor was started up and Hindley inspected it at intervals during the shift. His last inspection of the belt was made at 8.30 p.m. A full shift of coal had been transported without mishap and arrangements were made for Hindley to stay overtime to repair the belt. These arrangements were cancelled, however, because H. Godfrey, the overman in charge of the district on the night-shift, finding that a length of coal on No. 65's face had not been filled off, gave instructions for the belt to continue running until the coal was cleared.

When Jos. Morris, the No. 3 transfer point attendant, arrived at his place of work at the start of the night-shift about 11 p.m., he examined the No. 2 belt and estimated that the grooving extended for upwards of 200 yards and that for a length of 6 to 8 yards the belt was cut through. He said he was able to push his hand through the slit. The condition of the belt had clearly worsened since Hindley had made his inspection at 8.30 p.m. Nevertheless, the belt was started up and nothing untoward was observed until 3.10 a.m. when Morris signalled to W. H. Hird, the attendant who was stationed at the telephone 70 yards on the outbye side of No. 2 transfer point, to stop the No. 2 belt. Hird did so and Morris then telephoned Hird via the pit-bottom exchange and told him that the belt was torn and had a "trailing end." He arranged to travel outbye while Hird travelled inbye so that they could find where the damage to the belt had started. Morris set off and when about 400 yards from No. 2 transfer point he encountered smoke, and when still 150 yards away he saw fire at the transfer chute and flames between the chute and the sidewall of the roadway.

Hird travelled inbye no further than the 70 yards to the No. 2 transfer point where he saw the transfer hopper full of torn belting, looking, as he said, as "if three or four men each side . . . had been laying it out." He returned to his telephone, informed the man in charge of the pit-bottom telephone exchange what had occurred and asked to be put in contact with Godfrey, the night overman in charge of the South-West District. During this time the No. 1 belt continued to run although Hird stated that he had signalled for it to stop. A few minutes later Hird saw fire in the chute at the transfer point and again telephoned to the pit bottom to ask for the electric power to be cut off help to be summoned. He had just completed this telephone call when Jos. Morris arrived and asked him if he knew the transfer point was on fire. Hird said he did and looked at his watch. It was then 3.45 a.m. From the time No. 2 belt was stopped until the fire was discovered, Morris had travelled nearly 1,000 yards, including 350 yards up a drift rising at 1 in 9, examining the conveyor structure and belt on the way. Hird, although the first to see the fire, made no effort Morris, on the other hand, as soon as he arrived, asked about the portable fire-extinguishers. There were two at the nearby 59's junction. He applied the first with little effect, and the second failed to function.

The fire-station was on the inbye side of the No. 2 transfer point and soon became inaccessible because of the fire. When the station was first established it conformed to the normal and good practice at this colliery, in that it was sited on the intake side of the vulnerable point, because it then served the old 59's junction which was 260 yards inbye from it. Even if the fire-station had been on the outbye side of the transfer point, it is doubtful whether—in the circumstances of this fire—it would have altered the course of events. Before the actual fire was discovered by Hird and Morris, the strips of torn belting within the metal enclosure of the chute were, in my view, so well alight and so relatively inaccessible, that portable fire extinguishers or buckets of sand or water would have been of little use. And with the knowledge we now have from the experimental fire at the Buxton Research Station, the burning of the torn belting would develop so rapidly and fiercely that nothing short of a copious water supply at adequate pressure would have met the situation. Nevertheless, when the position of machinery or material with a potential fire risk is moved, the site of the fire-fighting equipment should be moved to meet the new conditions, otherwise the equipment loses much of its potential value.

Immediately on receipt of Hird's telephone message about the fire, F. Kirk, the pit-bottom telephone-exchange attendant, sent telephone warnings of the fire into the South-West District and calls for fire-fighting teams from other parts of the mine. The manager and undermanager were also informed. It was now 4 a.m. Messages were then sent for the Central Rescue Brigades at Chesterfield, senior local officials of the National Coal Board, H.M. Inspectors of Mines and officials of the mine-workers' Unions. When the undermanager got to the pit, he spoke to the manager at his home by telephone, and then went underground. Having received assurances that the inbye workmen had been warned of the fire and were on their way outbye, he went straight to the scene of the fire. There he found that some members of the pit fire-fighting teams, led by J. Rodda, overman in charge of the North-West District, had been in action since shortly after 4 a.m. They had travelled in the "Paddy" in the return airway, taking with them a supply of fire-hoses and nozzles. The fire-fighters at once coupled up their hoses to the water main but got little more than a trickle of water which was quite ineffective.
efforts with the hoses were described at the Inquiry as "just like standing in a garden watering flowers." The water supply at normal quantity and pressure had unexpectedly and, for the time being at least, unaccountably failed. Repeated telephone messages for an increased supply brought no improvement. As soon

as the undermanager arrived he also telephoned instructions for the source of the trouble to be fully investigated without delay. It was now about 5.15 a.m.

In the meantime, supplies of portable fire-extinguishers, sand and stone dust were collected and sent to the scene of the fire and used very effectively. So much so, indeed, that the impression was gained that the main fire had been got under control, with the result that a message was sent to the surface that the fire was nearly extinguished. Unhappily, this was not the case. The steam and smoke in the roadway had reduced the visibility to practically nil and had masked the spread of the fire along the roadway, an extension which, no doubt, had been accelerated when the burning No. 2 belt—still under tension—broke and the burning end sprang inbye.

At 5.20 a.m. a team of trained rescue brigade men from Chesterfield Rescue Station arrived at the fire. But because of the lack of an adequate supply of water under pressure, they were unable to do any really effective fire-fighting work. While the other fire-fighters continued their efforts with the portable fire-extinguishers and the little water still available, the rescue brigade men donned their liquid-air apparatus and tried to get past and ahead of the fire in an attempt to prevent it from spreading further inbye. But the heat was too intense and the attempt failed.

The lack of an adequate water supply under pressure was later found to be due to a set of most unfortunate coincidences. As previously indicated, the underground fire mains were supplied constantly with water by a 1-inch pipe from the No. 2 upcast shaft, but this quantity was only sufficient to maintain the dust-suppression sprays. For the much larger quantity of water needed for fire-fighting, reliance was placed on the 5 inches diameter rising main in No. 1 shaft. During the night-shift, this main was continuously fed with water from the Top Hard pump but during the other two shifts the water supply was fed into the main from surface tanks through suitable valves. The routine control for the change of water supply to the shaft main was well established under normal conditions. Unfortunately, for the first time for many years, the Top Hard pump failed to start at the commencement of the night-shift of the 25th/26th September, 1950, and the fitters who examined it considered that it could not be repaired during the shift. Although the pump-man informed H. Godfrey, the night overman, of the breakdown, neither the pump-man nor the fitters thought it necessary to inform any surface official and so nothing was done to adjust the surface valves to ensure that the main was fed with water from the surface tanks.

Thus it happened that when the fire hose was coupled to the fire-main near the seat of the fire—which was about one mile inbye and 175 feet above the shaft bottom level—the water supply was almost negligible, partly because little or no water was entering the shaft rismg-main and partly because of the pressure absorbed in overcoming the static head and pipe friction. This water-supply system had been provided at considerable cost in time and materials and was considerably above the standard found in many collieries today. Its failure at a critical time—indeed the only time it had ever been required to deal with an underground fire—proved disastrous and costly. This experience demonstrates the need for a careful review of the fire-fighting water supply at collieries to ensure that an adequate supply of water at sufficient pressure is constantly available at all points in the fire-fighting water mains. For this purpose, the fire mains should be of adequate size and should be supplied from a source feeding directly and continuously into them. Tests should be made at suitable intervals to check the quantity and pressure of water available, and the pressure of the water supply at any transfer point should be measured at the beginning of each working shift. A conveyor should not run if the supply of water is inadequate.

The water position was not rectified until a considerable time after the arrival of the colliery engineer about 5.10 a.m. ; but by the time a reasonable supply of water was available, the fire in the chute at No. 2 transfer point had burned itself out, and the fire had spread a long way inbye. Water was still necessary, however, to cool down the hot material and smouldering wood. Another attempt was made to reach the advancing fire by working forward along the roadway, but because of damage to roof supports, the effect [illegible] and water on the strata and the deterioration of roof and sides, conditions became too dangerous to allow the attempts to continue. Later, temporary supports were set in the hope of reaching the advancing fire, but only 60 yards of roadway were recovered when, for reasons given later, the erection of the seals became essential and stopped all further fire-fighting and recovery work.

While all this had been going on, several men from the inbye workings in the South-West District had come out safely by way of the main-return airway. And then, about 5 a.m., another inbye workman, J. W. Turner, who had been working on 65's face, came out of 59's loader gate. He had travelled by the main return to 59's right-hand return, over the overcast on the main intake and then along 59's right side face. On his way he had opened the doors at the overcast and saw the fire raging underneath it. He was in a distressed condition and reported that there were more men behind him. The fire had thus travelled at least 125 yards inbye in about 1¼ hours.

It was now realized that the inbye men were not getting out as expected and rescue teams were at once sent in to explore the main return. They found one body about 500 yards inbye from 59's left return gate and brought it to the fresh-air base. Artificial respiration was tried but there was no response. Eventually, the rescue teams brought out two other bodies and reported that they had seen ten more.

By this time the smoke in the main return at 59's left side return gate was extremely dense and had a very bad effect upon the eyes of the rescue men. Moreover, the effect [illegible] teams showed that the atmosphere was so deadly that it was impossible to conceive of anyone being alive in the inbye workings. It was decided that, except for an exploration of the main return towards the shaft, rescue work should be stopped for the time being. The return airway was explored towards the shaft bottom but the rescue team reached the stable slit without finding anyone.

A conference of representatives of the National Coal Board, the workmen's Unions and the Inspectorate was now called to discuss the position and decide future action. It came to the unanimous conclusion that, since no one could be alive on the inbye side of the fire and since the dangerous condition of the roadway precluded fire-fighters from reaching the fire-front to prevent the fire from spreading further inbye, the only possible way of extinguishing the fire and of avoiding the risk of a firedamp explosion, was to seal off the district. The sites of the seals were agreed and arrangements made for improving the haulage facilities to transport the necessary building materials inbye. During this period the rescue teams were having a well-earned rest.

An examination of the main return at the stable slit indicated that the smoke was now much less dense than formerly and that the effect [illegible] less severe. It seemed as if the intensity of the fire had somehow become suddenly reduced. A further examination was then made of the scene of the fire and of the main return at 59's left gate. The outbye end of the fire area had considerably cooled down but because of the dangerous condition of the roadway the advance of the fire inbye along the belt road could not be ascertained. A second examination revealed that the smoke in the return was definitely less dense. Discussion took place as to the possibility of recovering the ten bodies that had been previously located by rescue men, and it was unanimously agreed that this should be done. More bodies were found just beyond the point where the ten bodies were lying, and, altogether, 47 were recovered. There was no worsening of the condition of the atmosphere in the return airway and it was possible to send in more rescue teams to explore the inbye slits connecting intake and return. In each case the rescue men reported that they were unable to travel these slits because of heat, smoke, and deterioration of roof conditions. This information not only made it inadvisable to send rescue parties further away from the fresh-air base but also emphasized the need to build the seals as quickly as possible. By this time the outbye haulage arrangements were functioning properly, and sand-bags and supplies were ready to come inbye in quantity. In addition to recovering the 47 bodies, the rescue men located 27 others, leaving six more to be found.

IV.—SEALING-OFF AND SUBSEQUENT RECOVERY OPERATIONS

The site chosen for the two initial seals was a short distance inbye the stable slit and fully 1,000 yards from the pit-bottom. The stoppings were built with sand-bags. The intake stopping was 8 yards long and the return stopping, which had to be built under difficult and very trying conditions by men wearing self-contained breathing apparatus, was 7 yards long. Each stopping was fitted with a 2 inches diameter steel sampling tube and a 10 inches diameter steel ventilation pipe. During the building of each stopping, a tunnel, 3 feet square, was formed to maintain ventilation as long as possible. At one period during the building of the stopping in the return airway the rescue teams were man-handling sand-bags at the rate of 800 per hour. Two teams worked in the return, each for two-hour spells, but the work was so arranged that one team was being relieved every hour. The fresh incoming team carried the sand-bags to the site while the team previously transporting material for an hour, spent the second hour in actual building of the stopping. Sufficient sand-bags were taken close to the stoppings before commencing to fill in the "tunnels". This operation was timed to take place simultaneously in both stoppings. Similarly, when the tunnels were filled, the final sealing was completed simultaneously by bolting plates on the ends of the 10 inches diameter steel pipes. During these sealing operations, only the minimum number of men required to do the work and supervise it were permitted underground. After sealing, all persons were withdrawn from the mine and no one was allowed underground for 48 hours. Two days later, a careful inspection of the seals showed that they were in good order, and steps were taken to ensure that the air pressures on both stoppings were reasonably balanced. The outbye ends of the stoppings were then strengthened by the erection of brick walls, 3 feet thick.

Thereafter, systematic sampling of the atmosphere behind the stoppings was carried out continuously. In time, the results of analyses of samples indicated that all combustion within the sealed-off area had ceased. A meeting of all the interested parties was held on 18th December, 1950, when it was decided to set up a panel of experts to plan a scheme for reopening the district and have it ready so that work could begin during the Easter holidays, commencing the 22nd March, 1951. It was thought that this would allow ample time for the strata to cool and also minimize any tendency to a recrudescence of the fire when the ventilation was restored. The plan was duly prepared and was submitted to and approved by another meeting of representatives of all the interested parties held on 23rd February, 1951. With the coming of the Easter holidays, the work of reopening began.

Rescue teams were used for broaching both seals, for preliminary exploration and for the erection of temporary stoppings at selected points so that the noxious and inflammable gases could be removed in stages. It was realized that methane would bulk very largely in these gases. Careful control of the quantity of air passing into the affected area limited the final methane content of the atmosphere in the upcast shaft and kept it below the lower limit of inflammability. As a further precaution, however, the fan evasée was extended to a height of 70 feet, so as to minimize risk of ignition on the surface and the possibility of recirculation of gas-laden air through the downcast shaft.

Operations proceeded according to plan until the district was cleared as far as the bottom of the Elmton Fault drifts, but the quantity of air available here was very severely restricted by an extensive heavy fall on the conveyor road between 59's timber slit and the compressor slit at the top of the Elmton Drift. Unfortunately, at this time, there was also a sudden drop in the barometric pressure which liberated gas from the inbye panels and, because of the restriction due to falls in the conveyor road, the available ventilation was unable to cope with the new conditions. In these circumstances, it was decided to seal off the district once again, but before doing so, 27 bodies were recovered and two more located. This time the seals were built in both roadways at the top of the Elmton Drifts.

During the exploration of the roadways, it was established that the fire had extended from No. 2 transfer point to the outbye side of the compressor slit—a distance of 610 yards. The position of the new seals, therefore, allowed for a full inspection of all the fire area and enabled the conveyor road to be repaired so that full ventilation would be available for the final clearing of the working panels. This was effected on 10th August, 1951, and the remaining six bodies were recovered.

In all these operations, as in the earlier work, the rescue teams drawn from a wide area did a fine job, working with diligence and courage, and performing hard and hazardous tasks without any untoward incident. It is noteworthy that some teams travelled as much as 1,500 yards away from the fresh-air base, thus making a total journey of 3,000 yards.

The work of the Area Scientific Department of the National Coal Board in relation to air sampling and analysis during the rescue and recovery operations is worthy of record. The staff dealt with more than 1,000 samples. To begin with the analyses were made in the laboratory at Bolsover, some miles away. When for a period it was found desirable to take samples at intervals of 15 minutes throughout the day and night, it was decided to convert a room at the Creswell offices into a temporary laboratory. This arrangement proved highly satisfactory when the district was being sealed off, and especially during the building of the stopping in the main-return airway. As the tunnel in this stopping began to function, the flame-safety lamp tests made by the rescue men began to indicate increasing percentages of firedamp in the air, and at one time as high as 3 per cent. This was disturbing in an area where there was known to be an open fire in the vicinity. Laboratory analyses of samples never showed more than 0.5 to 0.6 per cent., and there is no doubt that the large number of samples taken and the early report of the results of analyses from the laboratory did much to create a feeling of confidence in the men in the danger zone. It would appear that the dust raised by the high-velocity air passing through the tunnel in the stopping had the effect of elongating the gas-cap of the flame-safety lamp.

By their systematic sampling and analysis and their interpretation of the results of analyses, the scientific staff greatly helped those in charge of underground operations not only to determine when to reopen the district but also how much air to circulate to ensure that, when the inbye workings were being cleared of inflammable and noxious gases, these gases were diluted to harmless proportions.

V.—EXAMINATION OF THE FIRE AREA

As soon as conditions allowed, a careful and detailed examination was made of the area covered by actual fire. The No. 1 belt was burnt through. The burnt end of the top belt was found 48 feet from the outbye end of the centralizing hopper where it had apparently continued to burn or smoulder until it was extinguished at a set of idler rollers. The burnt end of the bottom belt was found underneath the chute structure of the No. 2 transfer point about 5 feet from the outbye end of the hopper. The coal-carrying side of this bottom belt was burnt in several places for a distance of 7 feet from the burnt end and part of the rubber cover was stripped for a distance of nearly 95 feet from that end. When the two burnt ends were brought together on the surface they did not match. Nevertheless, although some part of this belt had been consumed by the fire, there seems little doubt that most, if not all, of the distance between the burnt ends could be accounted for by the fly-back when the belt burnt through whilst under tension.

The casing of the chute and centralizing hopper showed signs of heating, as all the paint was burned off except for a little at the outbye end of the centralizing hopper and underneath the sloping-chute plate. The roof and sides over most of the chute-unit were supported with steel girders resting on wooden-end props, with wooden lagging. The props, though charred on the surface in places, had continued to give adequate support to the roof, but the lagging had burnt and charred remains were found. Two pieces of charred lagging were found resting on idler rollers. The possibility that this wood, heated by friction against the rollers, might have started the fire, was considered, but was ruled out because, among other reasons, it seemed certain that the wood had fallen out of position after the fire had started.

Up to slightly above the level of the No. 2 belt delivery roller, and sloping downwards outbye, the chute was found filled with debris which extended down between the idler and impact rollers of the No. 1 belt below. All of this material was carefully collected, sent to the surface and weighed, and then dispatched to the Safety in Mines Research Station at Buxton for sieving and a more detailed examination. It was found to comprise : stone-dust and powdered-charred belting (passing through ¼ inch mesh), 2,010 lb. ; lumps of stone, 464 lb. ; unburnt and partly burnt belting, 254 lb. ; charred-wood lagging, 35 lb. ; old nuts and bolts, 1 lb. 13 oz. ; and white metal from idler rollers, 10½ lb.

When most of this material had been removed from the chute, it was seen that, between the top edge of the sloping-chute plate and the No. 2 belt delivery roller, a quantity of torn belting was very tightly wedged and looked as if it had been pulled in by the moving No. 2 belt. The chute plate was dropped and the wedged pieces of torn belting more closely examined. The surfaces in contact with the remains of the No. 2 belt and, at the side, in contact with the metal surface of the delivery roller, were found to be worn by friction. The piece of No. 2 belt still remaining in contact with the delivery roller, and conforming to its curvature, was unburnt. It was full width and not grooved, but the rubber surface was severely worn and showed an imprint of the trapped belting.

After the chute and the piece of No. 2 belt still adhering to the delivery pulley were removed, the pulley itself was rotated and found to be undamaged. There was plenty of grease in the top of each bearing which had not been hot enough to melt the grease. An examination of the surface of the pulley showed no indication of slip between belt and pulley.

Altogether, 43 pieces of belt longer than 8 inches were recovered from the chute debris. Of these pieces, ten, varying in length from 12 inches to 54 inches, showed a cut through one surface rubber and through all seven plies of canvas, but in no case was the cut through the last layer of rubber. The cut was consistently $5\frac{1}{2}$ inches from one edge of the belting. Fifteen of the other pieces were $5\frac{1}{2}$ inches wide. On the No. 1 conveyor, with its outbye end torn, another piece of belting 43 feet 8 inches long, was found.

This evidence suggested the possibility, indeed the probability, of a fire having started at the top of the chute plate by frictional heating between the wedged torn belting and either the No. 2 delivery roller or the No. 2 belt, as it passed round the roller.

The top of the chute plate was found to be bowed downwards with a maximum deflection of $5\frac{1}{2}$ inches about 15 inches from the left side looking inbye. When the chute was disconnected it was found that, at the point of maximum deflection, there was a gap of $1\frac{1}{4}$ inches between the chute and the 2 inches by $\frac{3}{8}$ inch iron strip by which the belt wiper was fastened to the chute. The wiper was found to be worn away until it was level with the edge of the chute, which was about $1\frac{3}{16}$ inch from the face of the No. 2 belt delivery roller. One of the eight bolts, by which the iron strip had originally been fixed, was found to be missing at the gap. Pieces of torn belting in this gap had pushed the belt wiper away from the edge of the chute and had also bent the strip of iron between the second and fourth bolts from the left-hand side. Whether this missing bolt and gap had been of long standing or were the result of the happenings immediately before or during the fire, can only be a matter of conjecture. In any case, I do not consider they had any material effect on the course of events.

A heap of stone was found on the floor near the delivery end of No. 2 belt. This suggested that there had been at some time a " pile-up " in the chute due to No. 1 belt being at rest while No. 2 belt was delivering stone. All the belt rollers and their bearings of both Nos. 1 and 2 conveyors in the vicinity of the No. 2 transfer point were examined in great detail. Several were found to be damaged, usually by the melting out of the end alloy discs containing the ball bearings, but this damage was considered to be the result of the fire. In no case was there any suggestion that heating at a roller bearing was a probable or even a possible cause of the fire. Nor was there anything to suggest that either the tensioning gear of the No. 1 belt, or the driving gear of the No. 2 belt had anything to do with the start of the fire. On this gear-head were found two small pieces of belting, neither of which showed the signs that would have been expected if the fire had started at the gear-head by the friction of a jammed belt. On the floor, just inbye of the chute, was a heap of coarse coal dust which had taken no part in the fire. It was covered by a white deposit which appeared to be the remains of the charge of a foam extinguisher.

Except for odd pieces of charred belt, and one piece of the top belt, 9 inches by 4 inches, which was found under a stone presumably carried by the top belt, the No. 2 conveyor belt was completely missing for a distance of more than 30 yards on the inbye side of its delivery head pulley. It was at this point that falls of ground began to be encountered. These falls had to be cleared to permit exploration and assist ventilation. A few pieces of unburnt belt were found underneath the falls. At a wet place a piece, 39 inches long, had presumably been protected by a pool of water. Some steel arch girders had become so hot that they had twisted under load. The loader gate of old 59's district showed signs of heating for a distance of 60 feet but the fire had not travelled down it. Near the Timber Slit, two pieces of top belt, about 8 feet long, were found, having apparently been protected by small falls. At a point 500 feet from the Timber Slit two larger pieces of top belt, 16½ feet and 21 feet long, separated by a distance of 9 feet, were recovered. This was at the site of a large fall of roof and it seems likely that here the fire received a check and propagated only along the bottom belt which would be protected by the conveyor structure forming a tunnel through the fall. It was probably this " lull " which made most of the early recovery work possible just prior to the erection of the first stoppings to seal off the district. The fire did, however, pass this obstacle and there is no doubt that had the seals not been erected at the time they were, the fire would have spread much farther than it ultimately did. A short distance beyond this point and near the top of the drift through the Elmton Fault, the burnt ends of No. 2 belt were found. The end of the bottom belt was found underneath a fall of roof and the end of the top belt about 50 feet farther inbye. From this point signs of heating decreased down the drift and finally died away near the roof.

From its burnt end, the top belt was found to be practically undamaged for a distance of 257 yards inbye. For the next length of about 100 yards to the No. 3 transfer point and then back along the bottom belt outbye to its burnt end—a total length of 469 yards—the belt was found to be torn or cut. Damage to the top belt started with three " sloughings " or " gougings " and a hole 8 inches long and ½ inch wide, about 5½ inches from the edge of the belt travelling road side. From the edge of this hole—and at the same distance from the edge of the belt—the belt was cut through for the whole of the distance to the No. 3 transfer point, with the strip of cut belt lying on the conveyor rollers alongside the remaining part of the belt. For a distance of 20 yards from the starting point, the edges of the cut showed occasional " sloughings " while other " sloughings " were seen on the 5½ inches wide strip. The cut was clean except that the rubber on the non-coal-carrying side had a generally jagged appearance. At distances of 8 and 10 yards from the start, the rubber on the under-side of the belt was joined across the cut for a length of ½ inch. This cut strip of belting terminated underneath the chute of No. 3 transfer point, and one end of the 43 feet long strip—found (as already mentioned) on the No. 1 conveyor outbye the No. 2 transfer point—matched perfectly with an end of the strip found at the No. 3 transfer point.

A strip of the belt was found to be missing for the whole length of the bottom belt from the No. 3 transfer point out to the burnt end at the top of the drift. For the first 204 yards, a 5½ inches wide strip was missing, leaving on the remaining belt a clean straight edge, having all the appearance of being cut by some sharp object, except that the rubber on the non-coal-carrying side was jagged. The width of the missing piece then suddenly increased for a short distance, indicating that cross-tearing had occurred. From subsequent observations, it seems extremely likely that it was at this point, i.e. when fully 200 yards of torn strip had collected in the chute while the No. 2 belt was still running, that the loose belt jammed in the No. 2 chute. For the next 100 yards, the width of the remaining belt varied and the edge was jagged, with the strip of belt missing varying from 7 to 9 inches. It was from this length that the grooved pieces of belting recovered from the No. 2 chute must have come, as nowhere else was the missing piece wide enough. This gave a clue to the condition of the belt immediately before the fire occurred and indicated that there had been a cut through all seven plies of canvas but not through the bottom rubber.

For the next 50 yards near the top of the drift, the remaining belt showed a clean cut edge, with a 5½ inches wide strip missing. Then followed about

70 yards of jagged edge belting with a strip, 1½ inches to 4½ inches wide, missing. This portion of the belt did not show any indication of being grooved. A straight cut edge re-appeared on the last 10 yards of the belt before the burnt end, except for a 12 inches length about 1 foot from the end.

At this point, the belt had apparently torn out to the edge, and there is no reason to suppose that it was other than full width from here outbye to the delivery roller at the No. 2 transfer point. Indeed, we have the evidence of Jos. Morris, that, from a point just outbye the top of the drift, the bottom belt was the full width to the No. 2 transfer point.

From the calculated area of missing belt, it was estimated that there must have been about 1,600 lb. of torn belting in the No. 2 chute at the time of the fire and that of this quantity, 1,350 lb. was burnt.

VI.—CAUSE OF CUT BELT

As already mentioned, the cause of the grooving and subsequent cutting of the belt had not been ascertained from the examinations made before the occurrence of the fire. Nor did the investigations underground after the fire reveal the cause. Experiments were therefore made to see if it was possible to determine the probable cause. The gear-head of the No. 2 conveyor was re-erected on the surface to operate a short length of conveyor. It was known that the No. 2 belt transported stone from rippings and that, among this stone, pieces of ironstone were occasionally found. Pieces of shale and pieces of ironstone, both from the South-West District, were held firmly and fed to the belt as it passed over the delivery roller. It was found that pieces of shale cut into the belt but soon splintered after several yards of belt had passed. As the shale was fed in, a cutting edge developed that was capable of cutting through two plies of canvas for a distance of little more than 50 feet. The chances of a piece of shale cutting evenly through 500 or 600 yards of belt to a depth of seven plies of canvas seemed very remote. When a piece of ironstone, however, was used, a cut of precisely even depth for a length of 200 feet—the limit of belt available in the experiment—was obtained. A shorter cut, but also to the limit of the length of belt available, was also obtained to a depth of six plies of canvas and part way into the seventh. After cutting, the ironstone was just perceptibly warm to the touch and, apart from being blackened by rubber, was practically unworn. It seemed evident that a piece of ironstone suitably wedged would be capable of continuing indefinitely to cut a belt to an even depth. It is important to note that although a belt was readily cut in this way, the appearance of the cut—even in broad daylight—gave no clue as to its depth. The belt had to be suitably flexed to determine the depth of cut.

From these experiments, a reasonable explanation of the damage and cutting of the No. 2 belt as found after the fire would appear to be as follows. A piece of ironstone had settled at the top of the No. 2 chute—probably due to a pile-up of stone when the No. 1 belt stopped while the No. 2 belt was still running—and became wedged against the No. 2 belt. At first it caused the "sloughings" and then, settling into position it caused the 8 inches long hole, cutting the belt right through to the delivery drum. The edge in contact with the steel drum became worn away, or the stone may have shifted slightly, so that it remained in a position to cut nearly through the belt.

VII.—THE FIRE: PLACE OF ORIGIN, EXTENSION AND CAUSE

The fire at the No. 2 transfer point was first seen there about 3.45 a.m. on the 26th September, by Hird and, a few minutes later, by Morris, attendants at the Nos. 2 and 3 transfer points, respectively. In its initial stages the fire was confined within the chute and centralizing hopper.

From his observations and deductions, a knowledge of the speed of the belt and of the ventilation and, for the later stages, of the speed at which Jos. Morris walked towards the No. 2 transfer point, Mr. S. Jones, of the Safety in Mines Research Establishment constructed the following time-table of the early stages of the fire. This is necessarily conjectural but in my opinion gives a reasonable picture of what probably happened in these early stages :—

Time	
0	Beginning of groove passes No. 2 delivery roller.
0 to 50 secs.	Groove belt passes over No. 2 delivery roller.
50 secs.	Groove belting tears through.
50 secs. to 2½ minutes	5½ inches strip accumulates in chute (620 feet).
2½ minutes	5½ inches strip jams and the belt tears across. (N.B.—This is a likely time for friction at the gear-head to start.)
2½ to 5½ minutes	Jagged-edge material accumulates in chute.
5½ minutes	Belt tears out to the edge.
10 minutes	Beginning of groove passes Jos. Morris (this is not a thing he would notice as conveyor has been running grooved all his shift).
11 minutes	Trailing end passes J.M.
11 to 11½ minutes	Signals to stop ; conveyor switched off ; slows down and stops. (N.B.—That with the braking effect of jammed belt in chute, the conveyor would stop quickly.)
11½ minutes	Conveyor stops. J.M. starts walking at two miles per hour.
11½ to 23½ minutes	J.M. walks 700 yards, and meets smoke.
23½ minutes	J.M. meets smoke (this smoke left the gear-head two minutes earlier, i.e. at 21½ minutes).
23½ to 27 minutes	J.M. walks 250 yards in the smoke and then sees fire.
27 minutes	J.M. sees fire.
27 to 29 minutes	J.M. walks 150 yards to fire.

2½ minutes	Belt jams	} 9 minutes for friction.
11½ minutes	Conveyor stops	} 10 minutes for smouldering.
21½ minutes	Smoke seen	} 5½ minutes for burning up.
27 minutes	Fire seen	

N.B.—The latter times (smouldering and burning up) depend on Jos. Morris' walking speed.

The first account of the extension of the fire was that given about 5 a.m. by J. W. Turner who reported that, when making his way outbye to safety, he opened the door of the air-crossing above the main belt-conveyor road in 59's right-side return airway, 125 yards inbye No. 2 transfer point, and saw flame. Later, at 7.50 a.m., when rescue men examined this air-crossing, the fire had then extended as far inbye as could be seen. After that, an attempt was made by rescue teams to determine the inbye extension of the fire by inspection through various slits between the return and the intake. The farthest inbye slit examined was at the bottom of the Elmton Drifts. Here the team reported that they encountered dense smoke and heat and that the roof in the slit near the intake was breaking up due to high temperature. There was, therefore, no accurate information of the extension of the fire before the district was sealed off. When the area was reopened it was found that the fire had travelled inbye for a distance of 610 yards from the point of origin and that the burnt end of the top belt was just beyond the inbye end of an extensive fall of roof. I am satisfied that the fire would have continued to extend had not the district been sealed off when it was.

The fire was undoubtedly extended by the burning of the rubber-conveyor belt along the roadway. Whilst the presence of some wooden supports in the vicinity of the No. 2 transfer point, and of wooden lagging used behind the steel girders and steel arches along the roadway, contributed to the size and intensity of fire, I do not think they helped in any way to extend it. Indeed, by burning away and thereby releasing falls of roof, the wood lagging may well have assisted in retarding the rate of extension of the fire due to the effect of the falls in reducing the quantity of air circulating over the fire. On the other hand, the dangerous condition of the roadway thus brought about was a material factor in preventing fire-fighters from reaching the advancing fire-front.

From the outset, the fire was thought to have been started either through a defect in the electrical or mechanical equipment or by friction. A thorough examination of the electrical equipment showed that the design, installation and maintenance were all of a high order and it disclosed no defect other than damage caused as a result of the fire. Nor was there anything to suggest that an electrical fault had suddenly developed. Electricity can therefore be ruled out. All the mechanical plant at the scene of the fire was first examined in the pit and then later dismantled and taken to the surface for closer examination. Detailed inspection of the No. 2 belt-head drive, No. 2 belt-delivery pulley, No. 1 belt-return pulley and all associated rollers showed no evidence of any of these having been the source of the fire. The bearings of the driving drums, the head pulley and return pulley were well greased and did not even disclose signs of excessive heat. Indeed, the drums were free to turn although they had been standing in the sealed area for six months. The smaller rollers showed signs of damage by the fire but nothing to indicate that they were the cause of the heating which started the fire. I am satisfied, therefore, that a mechanical defect in the machinery was not the source of ignition of the fire.

It now seemed that the most probable source of ignition was heat generated by friction within the chute or centralizing hopper at the No. 2 transfer point, and investigation was made to see how this friction could have arisen.

As already stated, when the No. 2 transfer point was very carefully examined, it was found that, despite the intense conflagration, some torn conveyor belting still remained and was tightly wedged between the edge of the chute plate and the delivery drum of No. 2 conveyor. Although a very small part of this wedged belting was in contact with the metal of the drum, most of it was wedged against the belting which still conformed to the curvature of the drum. Consideration of all the circumstances suggested that frictional heating might have arisen in various ways as follows :—

1. When the torn belting from No. 2 conveyor was passing forward down the chute plate, it might not have been carried away by the still running No. 1 conveyor but held fast in the centralizing tunnel. Thus frictional heating between the moving No. 1 belt and stationary torn belt from No. 2 conveyor seemed a possibility. Experiments simulating these conditions were carried out on the surface by the staff of the Safety in Mines Research Establishment with the co-operation of all parties, but they failed to get ignition from this source.

2. There might have been frictional heating by belt slip at No. 2 delivery drum. The No. 2 belt delivery drum was a driven roller depending on contact between the belt and drum for its rotation. Since the bearings of the drum proved to be in order after the fire, there was no reason for thinking that this drum did not continue to rotate throughout the period while No. 2 belt was moving. Moreover, the drum was free from any marks of scoring. There is, therefore, no evidence to support belt-slip as the cause.

3. There might well have been frictional heating between torn belt jammed between the edge of the chute plate and No. 2 delivery drum. With a strip of torn belt jammed in such a position, and No. 2 delivery drum still rotating, sufficient heat might be generated to raise the temperature of both drum and torn belting to the ignition temperature of the torn belting. Experiments carried out on the same gear-head at the surface of Creswell Colliery proved that this was possible, but the time taken to obtain ignition was much longer than the time within which the ignition underground must have occurred. I think, therefore, this cause can be ruled out.

4. Finally, there remained frictional heating between the moving No. 2 belt and jammed pieces of torn belting at the top edge of the chute plate which had been bent downwards. Detailed examination of the chute and torn belting showed that some pieces of belt had been jammed tightly against the No. 2 belt on the head pulley and that considerable wearing had taken place. The pressure had been such as to cause slight erosion of the moving belt, indicating that there had been heavy friction. Again, using the actual driving gear and head pulley, tests were made on the surface with a stationary belt pressing against the moving belt. Smoke was quickly visible and, in at least one test, smouldering occurred in 1 minute 55 seconds and fire 1 minute later—a total time of just under 3 minutes. The results of a number of tests showed that sufficient heat was generated during periods of time varying from 2 to 9 minutes to cause smouldering, while the periods between smouldering and fire varied from 2 to 20 minutes. These times fit in with the time which, it was estimated, would elapse from the moment the torn strip of belt became wedged in the chute until the fire was discovered.

Referring to these experiments, Mr. S. Jones of the Fire Research Section of the Safety in Mines Research Establishment, when examined by Mr. W. B. Brown, said in evidence at the Inquiry :

> " We found fires started in two places. The sample itself, which was wedged to the top of the chute plate, sometimes took fire ; even more often the abraded conveyor belt rubbed off the conveyor belting, which fell down in between the chute plate and the delivery roller on No. 1 belt. The abraded material was smouldering and took fire after it had fallen on to what was No. 1 belt."

In other words, this series of experiments, carried out with the equipment from the No. 2 transfer point, under conditions of pressure comparable with those likely to prevail in the chute at the No. 2 transfer point down the pit, showed that fires could readily occur by the heat generated by the friction of torn belting pressing against the moving belt on the delivery roller. The fires started at two places, (i) in the sample of torn belting itself, and (ii) in the small portions of abraded belting which fell on to the moving belt below. In one-third of the experiments the sample of torn belting caught fire and, in three-quarters of the experiments, the abraded material caught fire. In the latter case there is no doubt that the fire could be carried along the moving No. 1 belt until it came into contact with the torn belt piled up in the centralizing unit.

As a result of these experiments, I have no hesitation in coming to the conclusion that the fire underground was started by frictional heating of torn belting jammed between the top of the sloping chute plate and the moving No. 2 belt as it passed round the delivery roller at the top of the chute at the No. 2 transfer point.

In order to get some measure of the speed with which a fire in a chute filled with torn strips of the type of conveyor belting used at Creswell would build up, additional experiments were carried out in the underground gallery at the Buxton Station of the Safety in Mines Research Establishment. In this gallery, which is an arched roadway, 8 feet wide and 8 feet high, it was possible to control the ventilation, see the fire develop, get some idea of its intensity and some notion of the density of the fumes given off. For the purposes of the experiment, a two-thirds scale model of the Creswell chute was made at the colliery and installed in the gallery. It was then filled with a proportionate amount of torn belting of similar age and condition to that actually used in the pit. A fire was then started by igniting two ounces of abraded rubber from a piece of belting. In describing the results Mr. Jones said in evidence :—

> " With ignition at the top of the sloping chute plate, that is in the position where the sample itself would have fired, the flames spread downwards to the bottom of the chute plate and fired No. 1 belt in less than 8½ minutes after the fire was started. Ignited at the bottom of the sloping chute plate, the flames spread upwards in about five minutes, up to the top of the chute plate, then to No. 2 delivery roller, so the difference between ignition at the top and ignition at the bottom of the chute plate was no more than about 3½ minutes."

Speaking of the intensity of the fire in these experiments, Mr. Jones had this to say :—

> " . . . I can assure you that is, in a very short time, a very intense fire. That is, about five minutes from the stage where you can say 'well, the fire is going well and it is not likely to go out,' within five minutes you have the sides of the chute red hot and you have flames coming out of the mouth 12 feet long. . . . After another four minutes—that is to say a total of only 12 minutes right from the very beginning—we had difficulty, because the concrete roof of the roadway in which we were experimenting was starting to disintegrate ; quite a lot of the concrete was beginning to chip off due to the heat, sounding like a machine-gun going off, and we had to put out the fire."

It is perhaps of interest to record that, despite the intensity of this experimental fire in an underground roadway, it was in fact put out fairly quickly by the application of a good supply of water under high pressure. Here is what Mr. Jones had to say in evidence about it :—

> " For this purpose we used a 60 h.p. trailer pump, which will deliver 500 gallons a minute at 100 lb. pressure. I do not know the precise amount of water we were actually using, but we were using that pump which delivers 500 gallons a minute, 100 lb. pressure to a ¾ inch nozzle. I

should perhaps say we were not attempting to make an experiment at the putting out of this fire. That was not our intention. We were, I know, using a lot of water, a lot more water than most people could have in their pits. We were using water in the quantity that the surface fire brigades use it. We had water coming out from the nozzle with such force that it took two or three men to hold the nozzle still, because of the pressure of the force of the water. It was indeed a lot of water, and the fire was put out, of course, quite quickly."

With regard to the density of the fumes given off by the fire during the experiments, Mr. Jones described them as "extremely dense" but, when questioned by Mr. Miron, he was unable to give any information about their lethal properties as tests had not been carried out during the course of the experiments to determine their composition.

Since it seems highly probable that between 20 and 30 minutes elapsed from the time the torn belting started to accumulate in the chute until the fire was actually seen, it may seem strange that the attendant stationed near the No. 2 transfer point did not see what was happening and take effective action in good time to prevent danger from arising. Hird was questioned at some length on this matter.

To begin with, there was some doubt about Hird's actual duties. He was 49 years of age, possessed a deputy's certificate and was in receipt of compensation for injuries he had previously sustained to his nose, ribs and back. In evidence, he said these injuries affected his strength and his walking. At the time of the fire he considered his duties to be, not that of attendant at No. 2 transfer point, but of motor attendant at No. 2 belt, which was controlled from switches adjacent to the telephone situated near the entrance of 59's loader gate about 70 yards outbye from the No. 2 transfer point. No. 59's loader belt did not run at all during that shift. Hird was examined by Mr. Brown about his duties.

Q. What did you do with your time during this shift ?

A. Just operating No. 2.

Q. Stopping the belt when someone gave a signal, answering telephone calls and speaking to the pit-bottom operator as you thought occasion arose ?

A. During those gaps I was not answering the telephone because it never rang. It never rang until about half-past-three when they told me about going to meet Jos. Morris and about the torn belting.

Q. Are you quite satisfied there has been no misunderstanding between you and the official who mentioned that you were to stay beside the 'phone ? Do you think he really meant that you should spend the whole of the shift beside the telephone and not even walk a distance of 68 yards down to the transfer point to see whether things were right or wrong ?

A. I had always had instructions from Mr. Godfrey to stay by my 'phone unless told to go away or if he or Fred Kirk sent me on an errand, but I had to be told to go away from that 'phone. Mr. Godfrey has always impressed on me that the 'phone was my vital post.

Whatever Godfrey's instructions to Hird may have been, it was clear that the Manager did not agree with this description of Hird's duties and considered that he should have been spending part if not most of his time at the No. 2 transfer point. Had Hird done so the torn belting might have been detected in time and the fire prevented. Be that as it may, when Hird did discover the fire, his physical condition seems to have prevented him from taking any active steps to deal with it. He was examined by Mr. Brown on this point.

Q. I want you to think seriously of what I am just going to say to you Bill. If you had applied that extinguisher before Jos. Morris had arrived, was there a sporting chance that you could have quenched that fire ?

A. I could not have got up there in the state that I am in ; in fact, I cannot carry an extinguisher, not to be doing justice to myself.

Q. You mean to lift it bodily ?

A. To carry it bodily.

At first sight it would appear that only active persons trained in fire-fighting should be employed at conveyor transfer points and that it was wrong to employ at such places anyone suffering from the kind of physical disability which afflicted Hird. When questioned on this matter by Mr. Brown, the Manager had this to say :—

"Well, there are two snags there, and I speak from the Manager's point of view. Because of my trunk scheme, I have been rather curtailed for light duty jobs, and from humanitarian principles I have always used every transfer point for compensation men and light-duty men of all descriptions. It is practically the only way in which I can give these men employment. It has never been our practice to use for fire drills and fire-fighting teams men who are partly incapable, physically incapable. It has always been wrong in our opinion. These men should be physically incapable of doing fire-fighting and drills on a big scale. Therefore if we are going to consider this in the light of possible fires at transfer points I am afraid I am going to be cut out from using partly incapable men on these jobs, if you and others consider that all transfer-point men should be trained in fire drills. They may be trained in the method of doing fire drills, but it has been a bit difficult before from that aspect. We are prepared to give all transfer-point men some training in fire drill. but not to be always in a fire-fighting team. If that is the point, I would say yes. I would prefer now that every man should have some drill."

In this matter one cannot but feel a great deal of sympathy with the view expressed by Mr. Inverarity. At a well-designed, installed and maintained transfer point on a well-run conveyor system—such as was the case at Creswell—there is very little physical work for a transfer point attendant to do, and such a job would seem suitable for the employment of compensation or light-duty men. But whatever the type of person employed, I agree with Mr. Inverarity that transfer-point men should be given some training in fire-fighting and that every man should have some drill, and I recommend accordingly.

VIII.—WITHDRAWAL OF WORKMEN FROM THE INBYE SIDE OF THE FIRE

(a) Warning Arrangements

When a dangerous occurrence, such as a fire, is known to have arisen in a mine, the speed and urgency with which men will start to withdraw from any parts of the workings which may be endangered will depend very largely upon the action taken by officials or men on the spot who are aware of the occurrence. Action on their part will, in turn, be determined by (1) their knowledge of the situation, nature and extent of the dangerous occurrence and its probable effects on the safety of men ; (2) a proper assessment of the extent to which men's lives are endangered ; (3) the effectiveness of the arrangements by which warnings can be sent to the men concerned ; and (4) the use made of these arrangements.

In any warning system in a mine, telephones play an important part. Three telephone messages concerning the happenings at the No. 2 transfer point were sent by Hird to Kirk in the pit-bottom telephone exchange between 3.40 and 3.45 a.m. The first was to ask for fitters to attend to the damaged belt, the second gave warning that a fire had started and asked for a fire party to be sent in, and the third was a request for the electric power to be cut off at the pit bottom. Kirk attended to these requests and on each occasion had to leave his switchboard to do so. When the power was cut off, Kirk had to work in his exchange by the light of his flame-safety lamp. The fact that the power was cut off brought J. Rodda, overman in the North-West District, to the telephone to ask what was wrong. Kirk told him there was a fire at No. 2 transfer point and asked him to come as quickly as possible. Rodda then told Kirk to inform the Manager and Undermanager. Kirk also received a call from G. Cooper, deputy for 68's face in the South-West District, asking why power was off, and was told that it was because there was a fire at No. 2 transfer point. Kirk then telephoned to the surface to be put through to the Undermanager and the Manager at their homes and informed them of the fire, but he was unable at this time to give them any information about its extent. This was about 3.55 a.m. After that Kirk tried to contact Godfrey, overman in the South-West District, but on ringing the telephones at 64's, 68's and 74's, he failed to get a reply at that time. Shortly afterwards Kirk got a call from T. Severn at 74's telephone and told him to find Godfrey who was somewhere in the district. To quote Kirk's own words from the notes of evidence, he said to Severn : " Whatever you do, send scouts out to find him and tell him there is a fire at 59's transfer point and also contact the deputies and tell the deputies if you see them." It was not until about 4.20 to 4.30 a.m. that Godfrey spoke to Kirk. What passed between them is best told by quoting from the notes of evidence when Kirk was examined by Mr. W. B. Brown.

Q. And you passed on the message to him that there was fire at No. 2 transfer point ?

A. Yes ; I passed on the message to Mr. Godfrey that there was fire at No. 2 transfer point.

Q. Did he tell you he would arrange for a fire-fighting party ?

A. No, Sir, he just said on the 'phone, " Whatever has happened, Fred ? " I told him there was a terrible fire at No. 2 transfer point and he just said, " Good God " and dropped the receiver, and that was the last message I had from Mr. Godfrey.

Soon after Kirk had first spoken to the Manager and Undermanager at 3.55 a.m. he rang through to Hird and asked him for more information about the fire and was told that " it was getting well hold of the timber." Kirk then conveyed this information to the Manager. Kirk was examined by Mr. Watson on this matter.

Q. What time would that be ?

A. Well, it was straight away after I got that call. Well, I expect the Manager was on the 'phone waiting for the reply.

Q. Did at any time any of the officials on the surface, the Manager or the Undermanager, if the latter had spoken to you, ask you to 'phone inbye to get the deputy to get the men out ?

A. I cannot remember whether it was the Manager or the Undermanager who mentioned to get the men to the return, Sir.

Q. " Get the men straight to the return." That would be shortly after 4 o'clock ?

A. Yes, Sir, it would.

Following on these replies, Mr. Watson then questioned Kirk about his later conversation with the overman, Godfrey.

Q. Did you convey to Mr. Godfrey the Manager's instructions ?

A. No, Sir. He never stopped long enough.

Q. So you never got the opportunity to convey to Mr. Godfrey the Manager's instructions that all the men must be got to the return side ?

A. No, Sir, not to Mr. Godfrey.

Q. Did you speak to anyone in the mine round about that time and give those instructions on behalf of the Manager ?

A. No, Sir.

Kirk was further examined by Mr. Miron on this matter of telephone calls to the inbye faces in the South-West District.

Q. And then after you spoke to Mr. Godfrey did you speak to Mr. Hunt, Tom Hunt ?

A. I heard Mr. Hunt, yes, but his was a very faint voice, and he had told me that his men were on their way, and I presumed it was his fire-fighting party, and down his receiver went. . . . That was the only message, I presume, I got from Tom Hunt.

Q. And that was some time after twenty-past to half-past four ?

A. Yes, Sir, it would be.

Mr. Miron examined Kirk on the question of the accuracy of the various times he had given.

Q. Really, to be quite fair, on the whole question of times at this interval, and after the ordeal through which you went, you could not be certain of any times ?

A. No, I am sorry I cannot.

Q. Or indeed about the sequence of all calls made, when you first spoke to the Manager or the Undermanager and Mr. Godfrey, you could not really be precise ?

A. No. The Undermanager, when he came down, asked me to try and check the times of calls, but there were that many calls, it was impossible to keep the conversation going and take the times of all calls.

Kirk was also asked by Mr. Watson if he had received calls from anyone in the return airway.

Q. Did you receive any telephone calls of any sort during the course of the morning after the fire in connection with the running of the paddy mail ?

A. I got a call from out of the return, but I do not know what voice it was, calling for the paddy. I thought all power was off.

Q. Those who were telephoning were anxious to get out of the scene of the fire ?

A. Yes, Sir. It must have been someone asking for the paddy.

Q. Was it a strong voice—clear ?

A. Well, I should say reasonably. Just a reasonable voice, Sir.

Q. You have just told Mr. Brown your voice was affected by this fire ?

A. Yes, Sir, it was up to the last quarter-of-an-hour I was in—quarter-past-five.

Q. Was this voice something similar ?

A. Yes, Sir.

About 5 a.m. the atmospheric conditions in the telephone exchange were becoming intolerable. On this matter, Kirk was examined by Mr. Brown.

Q. Were you later affected by the fumes ?

A. Yes, Sir.

Q. Do you remember how you were affected ?

A. Yes. It seemed to catch my voice first. It was taking my voice. I had a bottle of water, and practically after every telephone message I had to have a little sip of water. I had only a drop left, and I had to make it last out, and then it caught me further in my body.

Q. Your legs ?

A. Yes.

Q. Your breathing ?

A. Yes.

Q. Were you then sent to the surface for more water ?

A. Yes.

Q. And who took your place ?

A. Charlie Howe, the day telephone operator and office attendant ; he came down about twenty-five past five, and we had a five minutes' conversation. I passed various messages on to him, and he said, " Have you any water, Fred ? " I said " No, Charlie, I have not got a drop left."

Q. So that right up to 5.20 a.m. you could breathe in the return and carry on a conversation ?

A. Yes. I was carrying on a conversation.

Q. Under difficulty ?

A. Yes, in the last quarter-hour it was under difficulties.

Q. And did you finally pass out, and were you put on a stretcher ?

A. I felt myself going after I had been up to the surface. I fetched three bottles of water from the Baths, and I got down the pit again with much trouble with the banksman who did not want me to come down, and I went back into the office. As I was proceeding through the doors I met two men carrying Charlie out. He had been overcome. They were carrying him into the main No. 1 bottom. I proceeded past them and into the office to try to carry on with the 'phone messages as there was no one in the office, and then two or three minutes afterwards I collapsed and got down on my knees, and I was making my way out of the office when I met Herbert Ross who was coming back there after taking Charlie out through the doors. I said, " Herbert, it's got me." He said, " Fred, get down on the floor and get through the doors into No. 1, if possible."

Q. And before you left the telephone exchange after returning from the surface did anyone come in for the purpose of arranging the plugs so that the exchange in the return was no longer necessary?

A. No, Sir ; not then.

The siting of the pit-bottom telephone exchange should be in the main intake so as to minimize the risk of its being fouled, as happened in this case. At some pits, it might well be housed on the surface. The manning of the exchange during a disaster, when instant action and the keeping of a full log are necessary, should be planned and arranged before-hand as part of the general plan of action in an emergency.

From this record of telephone communications there is clear evidence that knowledge that a fire had occurred at No. 2 transfer point was known by G. Cooper, deputy in 68's district, about 4 a.m., about 15 minutes after the fire had been reported, and that a few minutes later, T. Severn also knew and had been told to contact the deputies and let them know about it. Whether the overman, Godfrey, knew of the fire before he reached the telephone between 4.20 a.m. and 4.30 a.m. is not known, but it seems fairly certain that by this time the ventilating current passing the inbye telephones would be polluted to a visible degree with smoke and fumes from the fire.

In the early messages sent inbye it does appear that no emphasis was laid on the need for all men in the district to leave their place of work immediately and hurry out by the return with all possible speed. This lack of emphasis no doubt arose from lack of precise knowledge of the nature and extent of the fire and the knowledge that good fire-fighting facilities were believed to exist. But there is evidence that even when smoke was plainly visible, some of the men did not hurry. This was to some extent emphasized by the evidence of F. W. Tomlinson, who said he " walked slowly down 68's gate." It is significant that the only coal-face men who were able to reach safety were from 65's panel. This was largely due to the deputy, W. Morris, who sensed the serious nature of the fire and, after collecting his men together, stressed upon them the need for speed and led them to 59's left airway. In this way he brought 30 men to safety. Face rippers from 74's and erectors from 64's escaped because they had finished their work and were already on the way out when the fire was in its early stages.

It was suggested that some of the workmen were slow to realize the need for urgency because of the high standard set for the installation and maintenance of the conveyors, for the safety of the mine in general and the apparent excellence of the fire-fighting arrangements. These factors may have had some influence, but I think the lack of effective warning was a more important factor. Men were known to have spent time in dressing and in hiding tools and some of the victims even carried tools out as far as the top of the Elmton Fault. Had there been a feeling or sense of urgency, especially in the early stages, the death roll might well have been shorter. There is reason to believe also that several men waited for the " Paddy " to come inbye in the hope of getting a ride before starting off outbye, and it is known that several got into the " Paddy " when it arrived inbye, for bodies were found in the train. On the other hand, some of the men must have appreciated the urgency, because their bodies were found on the outbye side of the top of the Elmton Drift, although they were known to have been working on the most distant faces. Some of the victims had travelled more than a mile, and there is little doubt that they had been in a smoke-laden atmosphere for most of the time.

Whilst there is no doubt that early warning of the existence of a fire reached inbye districts by telephone, there was no evidence to suggest that this warning reached many, if indeed any, of the men on the inbye faces. This was due in some measure to the distance of the inbye telephones from the working faces, the nearest being 350 yards from 65's face and the farthest, 430 yards, in 74's district. Inbye telephones should be sited as near as is practicable to the working faces.

Nor was there any evidence to suggest that a message urging the immediate withdrawal of the men was ever received. The position seems to be that before anyone on the outbye side of the fire realized its serious nature and the danger threatening the men inbye, the dense fumes had already passed the inbye telephones and their attendants were on their way outbye. Because of these circumstances, it is highly probable that the men on the working faces first became aware of the fire when the fumes actually reached them and would come out on their own initiative and not be fully aware of the need for extreme urgency.

By the very nature of mining, men are not all concentrated together as in a factory and there must inevitably be a delay in getting a warning to them. When a source of danger arises, such as a fire, which is likely to endanger persons employed in other parts of a mine, it would clearly be an advantage to include in the code of signals for transmission by the signalling and telephone systems of the mine, a distinctive signal to indicate that a state of emergency existed which required the immediate withdrawal of the men, and I recommend accordingly.

It would usually be necessary in such circumstances to ensure that the men made contact with the official, if any, in charge of the district at the time, or with the person in charge of the nearest telephone, so that they could receive instructions how to proceed. For this purpose the alarm signal would have to be followed with the minimum of delay by a telephonic message to the district to indicate the subsequent procedure best calculated to ensure safety. To this end, as already indicated, it would be an advantage if the inbye telephones were sited as near to the working faces as was reasonably practicable.

If, in addition, an alarm signal could be given of such a nature that it could be heard by as many as possible of the persons threatened by the danger, it would be an added advantage. I was pleased to hear at the Inquiry that a firm of telephone manufacturers had co-operated with officials of the National Coal Board in the East Midlands Division in an effort to devise a method of transmitting through the telephone system a distinctive warning by means of a Klaxon horn. If an inbye telephone was reasonably near to the working face, the piercing note of the horn would probably be heard by someone on the face. It was the intention that the Klaxon would be sounded intermittently until the telephone was answered and information given as to the nature of the emergency and the procedure to be adopted. A fire-alarm of this sort would be an advantage and I commend the problem of devising such an alarm to research workers and electrical engineers.

(b) Ways and Means of Escape

The following table gives particulars in respect of the men employed (Plan No. 2) on the different inbye faces :—

Panel	Distance in yards from		Number of men		Number of men who escaped		No. of bodies located OUTBYE top of Drift		No. of bodies found INBYE top of Drift		
	Face to Top of Elmton Drift	Top of Elmton Drift to 59's left	Face	Road	Face	Road	Face	Road	Face	Road	
64	1,690	940	35	5	4	2	17	—	14	3	The four face men who escaped had already started outbye after finishing their work.
68	1,435	940	20	2	1	2	11	—	8	—	In this case the only face man to escape was the deputy, who had come out to find the cause of the power failure.
74	1,915	940	21	1	4	—	12	—	5	1	These four were face rippers who were riding out on the paddy train when the power failed.
65	1,195	940	36	1	28	1	6	—	2	—	This face received the smoke warning approximately 10 minutes earlier than any other unit.
On Main Roads	—	—	—	10	—	9	—	1	—	—	The one body was that of H. Godfrey, Overman.
			112	19	37	14	46	1	29	4	

The only way of escape for all these men was by the return airway.

In any assessment of the chances of escape, the speed at which the fumes and noxious gases from the fire travelled inbye must be considered (Plan No. 2). It cannot be assumed, of course, that the air current after passing the fire contained lethal amounts of noxious gases immediately, nor can it be said with accuracy when the concentration of carbon monoxide or other poisonous gases in the air current reached sufficient proportions to cause serious distress or death to persons breathing it. The estimated time taken by the smoke-laden atmosphere to reach certain points inbye may help to explain why more men from the 65's face than from the other faces escaped. The estimated time—based on the air velocity—for fumes to reach 64's junction was 7¾ minutes, and to reach 64's face, 27 minutes. By then the fumes had reached 74's face, had passed round 65's face and had reached the return airway. From this it will be seen that when the smoke and fumes on 64's face indicated that the position was serious, part of the return was already fouled. It would take about 34 minutes for the fumes to travel round to 59's left return gate but it is known that W. Morris brought 30 men to that point at 4.55 a.m., some 75 minutes after the fire started. By that time the concentration of carbon monoxide was reaching such a proportion that men were collapsing, as happened in the case of R. Walker.

It was most unfortunate that, at the time of the fire and just when the inbye men had great need to get outbye in a hurry, the man-riding arrangements in the main return were not running as usual because work was being done on the roadway and track. Some days before the occurrence of the fire, the run of the "Paddy" had been extended inbye to 74's cross-heading—a total run of nearly 2¼ miles. To ensure smoother running of the haulage, this necessitated an improvement in the grading of the roadway and track near the foot of the Elmton Drift. Work to this end was in progress at the actual time of the fire, and to assist the workmen in the handling of tubs at the job, a pony was employed. In order that the "Paddy" could be used to the best advantage whilst the work was in progress, one train was detached from the rope and left at the "meetings" so that the other train could run freely between the pit bottom and the outbye end of the repair job at the foot of the Elmton Drift. It was the intention, of course, that at the end of the shift the track would be left in running order, the second train would be reattached to the rope, and the "Paddy" would run as usual for the transport of the men at the change of shifts. Thus it was that, when the fire occurred, the "Paddy" was not in its usual running order and there was, in addition, a pony employed in the roadway. And when the inbye men reached the "Paddy" terminus in the return before the end of the shift they had no knowledge of the arrangements that had been made to run the "Paddy" under the exceptional conditions prevailing at that time. What actually happened in the return airway when the inbye men, whose bodies were found there, were on their way outbye can only be a matter of conjecture.

The sequence of events in relation to the movement of the "Paddy" after the outbreak of the fire was known seems to be as follows. The one train attached to the rope was travelling outbye with face rippers from 74's panel when the power was switched off about 3.45 a.m. When power was restored, the train was brought outbye to the terminus near the pit bottom. The train remained at the outbye end until the overman, Rodda, and his fire-fighting team went inbye with it to 59's left gate, where it remained for several minutes until, in response to the usual signal, it was brought outbye again. When it did reach the terminus the train was found to be empty. The haulage engineman, F. W. Hicks, then received a telephone call from 74's asking for the "Paddy" to be sent in, but by this time, smoke and fumes had already almost reached the engine-house at the outbye end of the return. The engineman started to run the train inbye when he received a signal of "1" followed by "10," indicating that a pony or ponies were travelling and he stopped the haulage. The train was then a short distance outbye from the stable slit. During this stop, a workman in the main return, Leslie Hancock, speaking from the telephone at the foot of the Elmton Drift, called Hicks and asked for the "Paddy." According to the Undermanager, Payton, who overheard the conversation while listening on another telephone, Hancock said : "This is Leslie Hancock, this is Leslie Hancock ; where is the train, where is the train. We are all about done here." That was the last time a voice was heard from the return airway. At least ten minutes later, although there is considerable doubt about this interval, the engineman received a signal of "10" and "2," and he started the train on its way inbye. It had reached the "meetings" when the fixed electric lights in the enginehouse failed. As the electric signalling system was supplied with power from the lighting circuit through a transformer, this meant that the signalling system was now also out of action. A few minutes later, the power came on again and the engineman once more started the haulage but the " Paddy " had only travelled inbye about 70 yards when the lighting and signalling systems again failed. When power was restored again, the engineman received a number of conflicting signals and, acting correctly, he did not start up the haulage but, knowing there was a telephone at the " meetings," he tried to get in touch by telephone with anyone who may have been in that vicinity at the time, but without success.

Ultimately, a clear signal was received from somewhere inbye and the engineman started the train once more on its inbye journey. When the train had reached the top of the Elmton Fault, the telephone rang and the engineman stopped the haulage to answer. It was a call from the Undermanager, who wanted to know where the train was and where it was going. The engineman gave him the information and started the haulage again, which took the train to the temporary inbye terminus near the foot of the Elmton Drift. Thereafter, no further signals were received from inbye nor was there any further telephone message : nor was it ever ascertained who gave the various signals for no one came out alive. And yet, when the train arrived at the terminus some men must still have been alive, for they had boarded the train.

By this time, the atmosphere in the enginehouse was so badly fouled with smoke and fumes that the engineman was partly overcome and was compelled to leave his post. He went about 30 yards towards a slit connecting the North-West District intake and return where he was revived by a leakage of fresh air. He was still within hearing distance of both the telephone and signal bells, but he heard no further signal. Had the enginehouse been ventilated by intake air, it would have been an advantage.

Whilst it may have been true that, in the telephone messages sent inbye to warn the men of their danger, there was a certain lack of emphasis on the great need for speed in clearing out of the district, I do not think there can be any doubt that once the men reached the main-return airway they would be only too well aware of their danger and would be most anxious to get outbye with all possible speed. That the " Paddy " could run only under the restrictions imposed by the repair work in progress at the time was bad enough, but that its movements were hampered by the presence of a pony or ponies and by the intermittent failures of the electric power and signalling systems—by which not less than 30 valuable minutes were lost—was a double misfortune. The reason for these failures of the electric power was never satisfactorily explained. Had the " Paddy " been able to run inbye without interruption when the first telephone message from 74's was received about 4.30 a.m. it was just possible that more men would have escaped. Wherever practicable, repairs which would interfere with the running of man-riding trains in an emergency should not be undertaken when a full shift of men is at work inbye.

It was difficult to avoid the feeling that, in the early stages of the fire, more thought and action were given to the fighting of the fire than to means of ensuring the escape of the men on the inbye side of the fire by way of the return airway. In a time of serious emergency when everyone is working under great stress, when conditions are wholly abnormal, and when most of the personnel engaged are not fully acquainted with all the local details, it is hardly right to criticize the actions of those engaged in dealing with the emergency or to blame in any way those who, without doubt, had no other thought in their minds than to give of their best. Nor do I intend to do so. Nevertheless, I feel it my duty to point out that when an emergency arises which endangers life and limb, the first duty is to see that everything possible is done to save life. This does not mean that nothing should be done to deal with the actual danger itself but it does mean that it should not take priority over life saving. Whilst the evidence showed that early warning of the fire was telephoned inbye and that the manager and undermanager had been assured that the men had been warned and were on their way outbye, there was no conclusive evidence to show that the inbye men had, in fact, received warning to withdraw without delay and there was nothing to suggest that a high official had been specially designated to see that every possible step was taken from the outset to facilitate their escape.

(*c*) *Provision of Two Intake Airways*

When a serious conveyor fire occurs in any mine in the intake airway of a ventilating district which has only one intake, then the means of escape for the men on the inbye side of the fire may well be cut off, since the return airway (or airways) will in time become fouled with the noxious products of combustion from the fire. The time taken to foul the return airways will depend very largely on the extent of the fire, the distances involved and the velocity of the air current. Since there was only one main-intake and one main-return airway in the South-West District at Creswell, and since the large fire occurred in the intake on the outbye side of the main production faces, the men at work on these faces on the night-shift of the 25th/26th September, 1950, had only one road—the main-return airway—along which they could make an attempt to escape. Moreover, the inbye production faces in the South-West required a large quantity of air for efficient ventilation and this quantity had to travel in beyond the fire along one road until it reached the first split at 64's face. Although the speed of the fan had been slightly reduced on the manager's instructions, nevertheless, the velocity of the air was still relatively high along this section of the intake and would, therefore, not only help to fan the fire but would carry the products of combustion rapidly inbye. The velocity of air in the single main-return airway for most if its length was also relatively high and, in fact, was not less than 500 feet per minute—a speed much in excees of that at which a man can walk on the level. But the men who were attempting to escape on this fateful night had to travel under very difficult conditions because the smoke of the fire reduced visibility, caused their eyes to smart and their throats to be irritated, while they had also to travel at one part for 250 yards up a gradient of 1 in 6—a part so aptly named by Mr. Watson, " the hill of death." It is obvious, therefore, that unless the inbye men received an urgent warning to clear out of the district very soon after the start of the fire, they stood little chance of reaching safety by walking the long distance to 59's left-return airway, because the fumes, travelling at a much higher speed than the men, would overtake them. This, in some measure, accounts for the heavy death roll.

There is little doubt that if a second intake had been available in the South-West District, the danger to the inbye men would have been reduced and their chances of escape greatly increased. With a second intake, the velocity of the air on the conveyor road would have been reduced and so the fire would not have been fanned so quickly; the speed of travel of the fumes inbye would have been reduced, thus allowing more time to send a warning to the inbye men ; and the provision of connections between the two intakes would have given the fire-fighters an opportunity of getting ahead of the fire and taking action to prevent its extension. To provide two main-intake airways to every main ventilating district of a seam would mean no more than compliance with the intention, if not the letter, of Section 42 of the Coal Mines Act, 1911, a Section which was based on recommendations made following an Inquiry into the disaster at Wellington Pit, Whitehaven, in 1910, when 136 lives were lost due to an outbreak of fire in a timbered main-intake airway.

With present methods of working and transport, the application of the double intake in many pits would require a good deal of thought in the planning and lay-out of the method of working and ventilation. Nevertheless, I am satisfied that for all major ventilating districts in a mine, the principle is right, that mining engineers can surmount the difficulties in its application and that the provision of two main intakes should be a statutory requirement for such districts in new mines and in new districts of existing mines, and I recommend accordingly.

I am pleased to report that, soon after the occurrence of the Creswell fire, the National Coal Board gave consideration to the question of the provision of two intake airways in all coal mines under their control, accepted the above recommendation and issued a directive to all managements to that effect on 9th July, 1951. A copy of this directive is given in Appendix III.

IX.—SUPERVISION OF TRUNK CONVEYOR SYSTEM AND OF TRANSFER POINTS

Considerable time was devoted at the Inquiry to discussing the important question of the supervision necessary to ensure safety in the trunk-conveyor system. Broadly, the question largely resolved itself into one of whether, in conjunction with the provision of safety devices of proved worth, it was sufficient to have a patrolling system under which a competent person or persons—the number depending upon the size of the installation—would keep the whole length of the belts and transfer points under observation during each working shift, or whether there should be, in addition to the patrolling system, a man in constant attendance at each transfer point.

The expert witnesses examined on this matter agreed that it was desirable to have a patrolling system and to instal at suitable places, such as transfer points and driving heads, effective automatic safety devices and conveyor control gear. If these measures were adopted then they did not think it would be necessary to require attendants to be stationed at all transfer points.

Whilst it may not be possible to provide automatic protection against all possible sources of danger that may arise in a chute at a conveyor transfer point, there are precautions which can be taken to guard against likely causes of danger such as the piling up of material in the chute or any condition which might give rise to overloading. With reference to these causes of danger, Mr. A. E. Crook, H.M. Principal Inspector of Mechanical Engineering in Mines, in evidence, suggested that "piling" could be prevented by either : (*a*) fitting in the chute a paddle connected to the electrical circuit of the motor, so that in the event of a pile-up, the paddle would move and break the circuit and then stop the motor ; or (*b*) sequence of control of the conveyors to ensure that a loaded belt does not deliver on to a standing belt. Mr. Crook also suggested that (i) the chute might be so designed and arranged as to prevent or minimize the risk of any material being trapped at the top of the chute or, (ii) in the event of material being trapped there, it would not cause fire. The first, he suggested, might be achieved by setting the chute well below the horizontal centre-line of the delivery pulley. But this method, as he pointed out, has the disadvantage that, by so doing, the free-fall of material would be increased and the dust problem thus aggravated. For the second, he proposed the use of the "hinged chute"—the Crossland device—in which a hinged plate is fitted to the top end of the chute and held in position by springs, so arranged that under abnormal load the springs extend and cut off the power driving the belt motor. To prevent ordinary overloading of belts, suitable overload protection should be fitted to the driving motor.

Most of these devices are, of course, well known, but they are not applied as frequently as they might be. As Mr. Miron pointed out, the Crossland device was, in fact, adopted at many Collieries in the East Midland Division and its use was extending. It has now been installed at Creswell. The adoption of automatic safety devices will depend upon the circumstances but most of them have an application in nearly all large trunk-belt installations. I commend them to colliery managements.

Mr. Crook, when questioned by Mr. Miron, had this to say:

Q. In other words—may I put it this way—if there is adequate supervision and sufficient electrical and mechanical safeguard over the conveyors at the transfer point, you would not recommend a static transfer point attendant?

A. I think I indicated in my suggestions that one could have the conveyor stopped by either automatic means or manual means, and then I went on to indicate about the transfer point attendant.

Q. Yes, let us be quite clear; if we have what you consider to be adequate mechanical or automatic means for the stopping of the conveyor you would not then seek to have one man permanently located at the transfer point?

A. I would not, with the proviso that the complementary point which I made was adopted, namely, that there was a competent person or persons in charge of the trunk conveyor system at any mine.

Q. Yes, there would be at all times, in addition to that automatic control, adequate supervision over the whole trunk conveying system?

A. Yes, that is my point.

Mr. Watson questioned Mr. Widdas, H.M. Senior District Inspector of Mines, at some length on the matter, as follows:

Q. . . . . One answer was not clear, and I would like to get it perfectly clear from you. Are you or are you not in favour of attendants being constantly at all transfer points?

A. On the broad question of that I am afraid my reply has to be "No," but I would say that if there is no safety device added in that chute, then it is "Yes."

Q. Let us examine this, because it is going to be an important part of this Inquiry. What safety device have you in mind?

A. The type of arrangement like the Crossland.

Q. Is it infallible?

A. Not entirely, but it would have prevented this type of fire.

Q. That is a point upon which I could not express an opinion. Is this equipment likely to go wrong?

A. All equipment from time to time can go wrong. That is as far as I can go.

Q. Therefore it would be necessary to have some attendants at transfer points?

A. I still cannot subscribe to that, provided approved, or if you like tested over a period of time, apparatus is provided.

Q. Did you hear Mr. Jones' evidence yesterday?

A. Yes.

Q. Did you note the time lag between the jamming and the smouldering?

A. Very short, I agree.

Q. Did you note that he said the scientist was alarmed?

A. Yes.

Q. Did you note that he said he ceased to be a scientist and became an ordinary bloke putting out the fire?

A. Yes.

Q. Have we any guarantee that the introduction of this Crossland device will prevent fires in the future?

A. We have to accept safety devices as such, and as long as they work they will prevent fires.

Q. Would you agree that someone should be at the transfer point to see that the safety device is working.

A. No.

Q. You would not agree that there should be attendants at the transfer points?

A. If safety devices are provided and we know that they will work. We regard the safety device as almost infallible, but it never is absolutely infallible, and I would say it is not necessary to have a transfer attendant always there.

Q. Can you tell us what you would have in their place?

A. Men patrolling.

Q. How far?

A. It would have to be very limited.

Q. As to what distance?

A. I would say probably to No. 2 belt. That would be 1,080 yards, and I think two patrol men could do that.

Q. That would mean that when they leave the transfer point they would travel 1,000 yards and back?

A. They would. (*Note:* It was later brought out that Mr. Widdas meant that the total distance travelled would be 1,080 yards altogether, i.e. 540 yards there and back.)

Q. Have you any idea how long that would take them to do?

A. Fifteen minutes, I would say.

Q. Did not this accident happen in less than fifteen minutes?

A. It did, but timing for the actual conflagration was definitely over 15 minutes. The fire was there within the fifteen, I agree.

Q. Therefore it is important, if the automatic device fails, to have someone who can see the fire?

A. Yes, but I think we are working on the very odd chance. We have electrical safety devices which do from time to time fail unfortunately, and yet we accept them.

Q. You are a man employed by the Ministry to safeguard the workmen, and I am asking you a frank question and you do not agree that there should be a workman in constant attendance at a transfer point if the other device is installed.

A. If devices are installed which we will accept as safety devices, just as we accept other safety devices in other methods of mining.

The trunk belt conveying system at Creswell was on a big scale and great care had been taken to instal and maintain the conveyors and especially to minimize the risk of fire. The structure was built up clear of the floor and rested upon concrete blocks ; the conveyors were in good alignment and all belt joints were vulcanized ; coal dust was cleaned up regularly ; the conveyor pans were liberally treated with limestone dust and at 5-yard intervals along the roadway there was a 56 lb. bag of stone dust ; and conveyor motor attendants were employed in preference to automatic sequence control, whilst in the case of No. 2 transfer point a cleaner was normally employed in addition to the attendant in control at 59's junction. Unfortunately, this cleaner was absent on the shift during which the fire occurred and his place had not been filled. So well had the plant been installed and maintained that it had run without a serious mishap since its installation at Easter 1948 until the time of the fire—a period of 2½ years.

A patrol system had not been established but the belts would come under the observation of the conveyor motor attendants stationed at or near the transfer points. The installation as a whole would be seen by the officials and deputies as they travelled the roadway. In addition, an experienced belt-maintenance fitter was employed to repair damaged belts. But whatever the nature of the supervision of the trunk-conveyor system at Creswell, this accident did not arise from a failure to detect a damaged belt. The belt-maintenance man had been called on the afternoon-shift to examine the known damage to the belt. He considered it could run during the shift under supervision and it did so. But he also considered it should be repaired at the end of the shift and, indeed, had received instructions from the afternoon-shift overman to work overtime in order to do so. The damage to the belt was therefore known to the overman in charge of the afternoon-shift, who said he reported it to the overman (now deceased) on the night-shift ; but neither of them seemed to think the damage serious enough to warrant a personal inspection. Most unfortunately, as it turned out, the night-overman seems to have countermanded the instruction for the repair of the belt at the change of shifts. It may be that he thought that since the damaged belt had run without mishap during the afternoon coaling shift, it could also run for the lighter duty required of it in the night-shift and could then be repaired before the start of the day-shift, and that, in any case, the worst that could possibly happen would be that the belt would fail and that transport would stop. I feel sure it never occurred to anyone that the damaged belt was likely to give rise to a fire. Nevertheless, it does seem wrong that a belt which was allowed to run on the afternoon-shift only under the supervision of the belt-maintenance man, was allowed to run without similar supervision on the night-shift. There is no doubt that those who actually saw the condition of the belt at the end of the afternoon-shift considered it should have been repaired before the night-shift started. But despite any mistakes or errors of judgment that may have been made, had there been a full-time attendant actually stationed at the No. 2 transfer point or had the chute at this transfer point been fitted with a safety device of the Crossland type, it is almost certain that the disaster would have been prevented.

This fire directs attention to the need for greater care in future in the supervision of conveyor belts and to the action that should be taken when damage to them is reported. When damage is reported, the belt should be examined as soon as possible by a competent official who should have authority to stop the belt and have it repaired without delay. The responsibility for such decisions should rest with an official and not on the shoulders of workmen, but a belt attendant should have authority to stop a belt, if he thinks the damage warrants it, until it has been inspected by the competent official, and I recommend accordingly.

On the question of supervision, after careful consideration of the matter, I have come to the conclusion that on all trunk-belt installations there should be a regular patrol system while the belts are working and for at least two hours after stopping, and either (*a*) automatic safety control devices fitted at all transfer points and driving heads, or (*b*) at transfer points where no such devices are fitted, a full-time attendant, and I recommend accordingly. With a patrol system in operation, it will be necessary to provide effective means of stopping a conveyor from any point along the roadway.

X.—CONCLUSIONS AND RECOMMENDATIONS

Following the failure to effect timely repairs to the badly damaged conveyor belt which resulted in torn strips of belting collecting in the No. 2 transfer chute, the disaster was due to four successive causes : (1) a rapidly starting and growing fire spreading in the main-intake airway ; (2) the failure of the fire-fighting arrangements ; (3) some delay in warning the men inbye : and (4) the main return was the only means of escape for the men on the inbye side of the fire. Unless fires on conveyor roads could be wholly prevented—and it is not possible to be sure of this—then there is potential hazard from them and it is necessary to consider how best this hazard can be mitigated by action under these four heads. There is little doubt that present practice in many mines leaves much to be desired and that it can and should be improved.

For the consideration of colliery managements and others in their efforts to prevent fires and the resulting hazards on trunk-conveyor installations where inflammable belts are used, I append a list of the more important matters to which I should like to direct attention.

1. *Prevention of Conveyor Fires*

(*a*) The roadway should be straight, well graded and large enough to allow ample clearance above and below as well as on both sides of the conveyor. Ideally, the largest lump of mineral conveyed should be able to fall sufficiently clear to avoid rubbing against the belt.

(*b*) All parts of the roadway where there are transfer points or driving units should be of fire-proof construction, extending for 5 yards on either side of such places. Non-inflammable material should be used for pillars supporting the conveyor structure, and the roadway, in general, should be kept free from combustible material and especially from accumulations of coal dust.

(*c*) As soon as they are proven in practice and are commercially available, only belts which are non-inflammable or are highly resistant to fire should be used.

(*d*) Automatic safety devices to prevent overloading, belt-slip, over-heating, and piling-up at transfer points and to detect damaged belts, should be developed and used.

(*e*) Attendants should be stationed at all transfer points not safeguarded under (*d*).

(*f*) Competent persons, specially trained for the work, should be appointed to patrol trunk-conveyor systems when in operation and for two hours after stopping.

(*g*) Effective means of stopping a conveyor from any point along the roadway should be provided.

(*h*) Substantial damage to conveyor belts should be reported forthwith and should be examined by a competent official who should have authority to stop the conveyor and repair the damage.

2. *Fighting of Conveyor Fires*

(*a*) The fire-fighting organization at every colliery should be thoroughly checked and improvements effected where necessary, and the need for speed in action should be emphasized. In particular, special attention should be paid to the training (which should include fire-drills) and the calibre of the fire-fighting personnel.

(*b*) Underground fire stations should be situated on the intake side of vulnerable points and when the material or equipment at these points is moved, the fire station should be moved to meet the new conditions.

(*c*) Persons stationed at transfer points or near fire stations should be trained in the use of the portable fire-fighting appliances provided and should be physically capable of using them in an emergency.

(*d*) Fire-fighting water mains should be installed throughout and the water should be supplied from a source which feeds into them directly and continuously. The fire mains should be capable of providing sufficient water at adequate pressure at any transfer point, and tests should be made at suitable intervals to check the quantity and pressure of water available. The pressure of the water supply at any transfer point should be measured at the beginning of every working shift and the result should be recorded. A conveyor should not run if the supply of water is inadequate.

3. *Warning to Men Inbye*

(*a*) Where the lives of men are endangered by a fire, a responsible official should be charged with the sole duty of seeing that the threatened men are warned without delay and that everything possible is done to facilitate their escape.

(*b*) There should be included in the code of signals used on telephone systems a distinctive signal to indicate that a state of emergency exists which requires the immediate withdrawal of the men. It would be an advantage if this alarm signal could be heard by as many as possible of the men threatened by the danger.

(*c*) Inbye telephones should be sited as near as practicable to the working faces and should be so placed that there is always someone in their vicinity during working hours.

(*d*) Underground telephone exchanges should be ventilated by intake air and arrangements should be made before-hand to have them specially manned in the event of an emergency.

(*e*) Repairs which would interfere with the running of man-riding trains in an emergency should, as far as possible, be avoided when a full shift of men is at work inbye.

4. *Means of Escape*

(*a*) Wherever practicable, there should be two intake airways and these should be provided for all major ventilating districts in all new mines or new developments in existing mines.

(*b*) Underground trials of improved forms of self-rescue apparatus should be expedited.

(c) As soon as an emergency arises, man-riding and other travelling facilities in escape roads should be cleared for action. This should be the responsibility of the official appointed under 3 (*a*) above.

(*d*) Where rope-haulage man-riding arrangements are situated in return airways, arrangements should be made, where practicable, to ventilate the haulage engine-house by intake air.

It is important to realize that, in so far as action under (1) for the prevention of fires is concerned—even though it might not be fully effective in all circumstances—there is much that could be done which would succeed in slowing down the initiation, growth and spread of a fire and which would so reduce the potential hazard to men inbye that loss of life would be unlikely. A high degree of resistance to fire would gain very valuable time.

There is, however, no short cut to success and what this disaster suggests is the urgent need for tightening up safeguards and precautions against fires at all stages. An over-riding condition of success in dealing with fires is the high calibre, thorough organization and full training of the personnel, and I emphasize that in general before passing on to other matters.

The Public Inquiry having been held up for more than a year by the sealing up of the fire, this Report is unavoidably belated and 18 months have now passed since the disaster occurred in September, 1950. But these were not months of inaction. Immediately after the fire, action on a national basis to strengthen precautions against such fires was being planned and was started by the Ministry of Fuel and Power and the National Coal Board—plans and action in which I had my part as Chief Inspector of Mines until the end of July, 1951, and in which, since then, I have continued to have my part as a Member of the National Coal Board.

In these circumstances, most of the recommendations that I have made have already been put forward and considerable progress has been made in putting them into practice. The plans and action now in progress have my agreement and I can best therefore conclude this Report by giving a brief account of what that action has been and how it is developing.

At its meeting on 4th October, 1950, eight days after the disaster, the Safety in Mines Research (Advisory) Board—the body, comprised of representatives of all sides of the Industry and of scientific thought outside it, which advises the Minister of Fuel and Power on matters relating to research on safety in coal mines—unanimously agreed the following resolution, drafted by its Chairman, Mr. E. G. Fudge, C.B., C.B.E., for submission by him to your predecessor :

> " That this Board, having discussed the problem of fire hazards underground in mines with particular reference to the Creswell Colliery Disaster and in the light of the knowledge and experience of its members, considers an extension of research into such hazards a matter of urgent necessity. It advises that this should take the form broadly of co-ordinated laboratory and field investigations undertaken jointly by the Ministry and the National Coal Board, and that the Ministry should enter into discussions accordingly with the interests concerned so that a concerted plan of research may be put into effect as speedily as possible."

Your predecessor at once accepted this resolution and directed that action should be taken accordingly without delay. This was done with the full co-operation of the interested parties and a comprehensive research and investigation programme on fire hazards at mines was agreed. This programme is given in Appendix IV.

So far as the National Coal Board is concerned, in addition to welcoming the opportunity to participate in the work outlined in the above programme, instructions were immediately given by the Board that colliery managements must intensify their efforts with the minimum of delay to reduce the hazard from underground fires. The action taken by the Board is summarized in its Annual Report for 1950, as follows :

> " To reduce fire hazards underground, the Board tightened up precautions at every colliery, water supplies and fire-fighting equipment were checked and the Board issued fresh instructions about the training of fire-fighters. fire-proofing of transfer points, regular patrolling of conveyor roads, the suppression of accumulated coal dust on conveyors, and the lay-out of telephones. Research into fire dangers, particularly those connected with the use of belt conveyors, was intensified. Various kinds of belting, including non-rubber belting, were put through laboratory tests for inflammability, and experiments were made in fire-proofing the cotton-duck base, which was found to be the most inflammable part of the belting. Tests were made on oils and greases used for lubricating conveyor rollers and the use of preventive appliances on equipment. In consultation with the machinery manufacturers, the design and construction of underground machinery were reviewed from the point of view of fire risk."

Action on these lines continued at the collieries during 1951, and is still proceeding. But much remains to be done.

As regards action by the Ministry of Fuel and Power, a new Research Section for research on fire hazards at mines was established before the end of 1950, at the Buxton Station of the Safety in Mines Research Establishment. It was this Section, under the charge of Mr. S. Jones, which was responsible for carrying out so well the experiments—previously described in this Report—(*a*) on the surface at Creswell, to study the probable cause of the cut belt and the source of ignition of the fire, and (*b*) in the underground gallery at Buxton, to get some measure of the rate of development of the fire in the chute. Among other researches undertaken to promote means of reducing the underground fire hazard, the Section has been very active in its investigation of the fire-retardant treatment of timber used for the support of mine roadways or for other purposes, and of the use of sprinkler systems or water barriers in suppressing or preventing the spread of conveyor fires.

It is also studying the effects of controlling the quantity and velocity of air upon the initial development and subsequent spread of a fire in an underground roadway. I welcome this investigation because the subject is, potentially, of much importance in relation to underground roadway fires and because so little appears to be known about it. The development of this work should include field work on a full scale at a suitable colliery.

Researches in accordance with the agreed programme are still continuing at the laboratories of the Safety in Mines Research Establishment and at the Central Research Establishment of the National Coal Board. Valuable assistance has been given by the Fire Research Station of the Department of Scientific and Industrial Research, where " spread of flame " tests on conveyor belt samples were carried out, and useful information on heating detector devices was obtained from the Royal Aircraft Establishment at Farnborough. Because of the special requirements imposed by use in gassy mines, few of these devices now in use in other industries are suitable, without modification, for use underground in coal mines.

H.M. Inspectors of Mines are closely associated with most of the work I have described and, in co-operation with the National Coal Board, the Research Organisations and some of the manufacturing industries, are using their wide knowledge and experience in promoting and facilitating progress at the collieries and new technical developments.

Research confirms that (i) the main risk of fire in the type of conveyor belting in ordinary use underground in mines lies in the cotton-duck foundation of the belt ; (ii) this risk can be reduced by fire-proofing the duck ; and (iii) the plastic poly-vinyl-chloride (P.V.C.) if used instead of rubber for the facing of the belt greatly reduces the risk of fire from the duck. Conveyor installations using this highly fire-resistant type plastic belting have been on trial underground for more than a year with promising results, and encouragement is being given by the National Coal Board to belt manufacturers to expedite production of this type of belting.

To prevent danger of fire arising from the heating of a conveyor driving head, a few manufacturing firms and the Central Research Establishment of the National Coal Board have designed thermostatic control devices which, when heated by radiation, cut off the current from the driving motor. Prototypes of these devices are being made for trials underground. Attention is also being given to the problem of reducing the risk of fire from the heating of an idler roller.

From this brief account of the work that has been undertaken since the occurrence of the Creswell Fire, it will be seen that active steps have been taken at the collieries and at the research establishments to minimize the underground fire hazard at mines, and that the work is continuing. I am satisfied that these efforts are well directed and have already resulted in a considerable raising of the standard of safety in relation to mine fires.

XI.—ACKNOWLEDGEMENTS

I desire to record my sincere thanks for the help and co-operation of the representatives of all parties to the Inquiry, and of Mr. H. Offord, Clerk of Court.

I am specially indebted to : Mr. W. B. Brown, H.M. Divisional Inspector of Mines and members of his staff ; Mr. A. E. Crook, H.M. Principal Inspector of Mechanical Engineering in Mines ; Mr. S. Jones and the staff of the Fire Research Section of the Safety in Mines Research Establishment (who provided many excellent lantern slides) ; Officials of the National Coal Board, East Midlands Division ; and the Draughtsmen and Surveyors who prepared a magnificent Wall Diagram and many other plans.

Finally, I should like to pay tribute to the heroism of many, known and unknown, among the workmen, officials, management and rescue teams during the many distressing hours immediately following the fire.

I have the honour to be, Sir,

Your obedient Servant,

A. M. BRYAN.

Appendix I.

LIST OF VICTIMS

1. BODIES RECOVERED ON 26TH SEPTEMBER, 1950

	Christian Names	*Surname*	*Age*	*Occupation*
1.	Leonard	Bower	38	Shot Firer
2.	Harry	Godfrey	51	Overman
3.	Horace	Attenborough	45	Packer
4.	William Henry	Bird	39	Ripper
5.	John Henry	Bowden	29	Meco Moore Operator
6.	Ernest	Briggs	33	Packer
7.	John William	Brocklehurst	44	Packer
8.	Robert	Brough	36	Cutterman
9.	Alfred Edgar	Bryan	56	Packer
10.	Herbert Stanley	Buckle	48	Gummer
11.	Sam	Cocking	42	Cutterman
12.	Ernest	Deakin	60	Gummer
13.	Ernest	Dodd	37	Ripper
14.	John	Dodd	45	Packer
15.	Fred	Doncaster	27	Conveyor Erector
16.	John William	Doxey	45	Packer
17.	George	Ellis	51	Packer
18.	Charles	Foulkes	49	Cutterman
19.	George William	Gillert	38	Ripper
20.	Kenneth Amos	Goucher	42	Conveyor Erector
21.	Peter W.	Green	53	Packer
22.	C.	Hemingray	25	Conveyor Erector
23.	Cecil	Hendley	34	Cutterman
24.	Reginald C.	Holmes	44	Cutterman
25.	Arnold	Hutton	48	Packer
26.	J. T.	Jackson	58	Gummer
27.	Robert	James	52	Packer
28.	Ernest	Johnson	36	Packer
29.	E.	Johnson	46	Packer
30.	Reginald	Kirk	39	Ripper
31.	William	Mellish	55	Steel Supervisor
32.	Edward	Millward	44	Packer
33.	Ernest Leslie	Needham	44	Stone Contractor
34.	William Henry	Orvice	49	Conveyor Erector
35.	Kenneth F.	Robinson	25	Packer
36.	G. Sydney	Rogers	44	Ripper
37.	Victor	Rose	52	Cutterman
38.	Leslie	Rutherford	25	Cutterman
39.	Thomas J.	Senior	42	Packer
40.	J.	Shaw	56	Ripper
41.	Herbert	Shipley	38	Cutterman
42.	Thomas	Smith	51	Packer
43.	Thomas	Traylor	43	Cutterman
44.	Robert William Thomas	Walker	38	Packer
45.	C.	Ward	30	Packer
46.	Frederick	Whitlam	52	Packer
47.	George	Yearham	57	Face Timberman

In each case the cause of death was carbon monoxide poisoning.

2. BODIES RECOVERED ON THE 25TH MARCH, 1951

	Christian Names	Surname	Age	Occupation
48.	Leslie	Marshall	42	Deputy
49.	Reginald	Teasdale	46	Supports Economy Officer
50.	William	Adams	51	Packer
51.	Frederick	Barker	41	Ripper
52.	Lee John	Buxton	59	Steel Supervisor
53.	Allen	Davis	63	Stone Contractor
54.	Leslie	Dodd	47	Ripper
55.	Thomas Henry	Evans	50	Packer
56.	Gordon	Fox	62	Ripper
57.	Leslie	Hancock	28	Packer
58.	James Arthur	Harrison	60	Cutterman
59.	Thomas	Hart	39	Datal
60.	John William	Humphreys	50	Ripper
61.	Albert	Lewis	46	Packer
62.	Edward	Limb	55	Datal
63.	John Henry	London	48	Ripper
64.	William James	London	51	Packer
65.	Albert Cecil	Mallender	47	Ripper
66.	William	Mellish	36	Datal
67.	Eric	Parkin	36	Cutterman
68.	Robert Idris	Price	34	Packer
69.	Arnold Loftin	Robinson	29	Packer
70.	James Lewis	Sadler	41	Ripper
71.	Thomas Arthur	Severn	46	Datal
72.	William Ernest	Stonach	36	Ripper
73.	Joseph	Taylor	42	Face Timberman
74.	George	Wass	37	Packer

In each case the cause of death was carbon monoxide poisoning.

3. BODIES RECOVERED ON THE 11TH AUGUST, 1951

75.	Thomas William	Hunt	51	Deputy
76.	Harry	Clarke	46	Ripper
77.	George Charles	Cope	59	Datal
78.	McDara	Connolly	28	Ripper
79.	John Edward	Oliver	53	Ripper
80.	Carey Gersham	Thorpe	46	Gummer

In each case the cause of death was carbon monoxide poisoning.

Appendix II

LIST OF WITNESSES

1. INQUIRY ON 17/18/19TH OCTOBER, 1950

	Name	*Occupation*
1.	Green, Thomas Archie	Mining Surveyor
2.	Hunt, Thomas Arthur	Medical Practitioner
3.	Inverarity, George	Manager
4.	Leah, Leslie Rawson	Underground Engineer
5.	Hindley, John Robert	Belt Maintenance Man
6.	Sherrard, Uriah	Pumper
7.	Martin, Joseph John	Chief Conveyor Electrician
8.	Clifford, John	Haulage
9.	Collingham, John Henry	Deputy
10.	Morris, Joshua	Belt Attendant
11.	Hird, William Hindley	Motor Attendant
12.	Noble, Joseph Spencer	Enginewright
13.	Ross, Herbert	Safety Officer
14.	Kirk, Frederick	Telephone Operator
15.	Hicks, Frederick Walter	Engine Driver
16.	Payton, George Samuel Ward	Under-Manager
17.	Morris, William	Deputy
18.	Cooper, George	Deputy
19.	Tomlinson, Frederick Walter	Belt Motorman
20.	Mason, James	Ripper
21.	Turner, John William	Packer
22.	Henson, Alfred Herbert	Charge Erector
23.	Brown, George Little	Manager, Central Rescue Stations, East Midland Division.
24.	Widdas, Walter	H. M. Senior District Inspector of Mines
25.	Whitehouse, William	H.M. District Inspector of Mines

2. RESUMED INQUIRY—27/28TH NOVEMBER, 1951

1.	Green, Thomas Archie	Mining Surveyor
2.	Turner, John William	Overman
3.	Betts, George William	Loader
4.	Rodda, John Edward	Overman
5.	Thompson, Fred	Dataller
6.	Hindley, John Robert	Belt Maintenance Man
7.	Rushton, George Wilfred	Maintenance Fitter
8.	Morris, Joshua	Belt Attendant
9.	Platts, Ernest James	H.M. Electrical Inspector of Mines
10.	Jones, Sydney	Principal Scientific Officer, Safety in Mines Research Establishment, Buxton
11.	Crook, Albert Edward	H.M. Principal Inspector of Mechanical Engineering in Mines
12.	Widdas, Walter	H.M. Senior District Inspector of Mines

Appendix III

NATIONAL COAL BOARD DIRECTIVE ON PROVISION OF TWO INTAKE AIRWAYS

1. The Board have decided as a matter of policy that the provision of two main-intake airways as required by Section 42 (1) of the Coal Mines Act, 1911 (subject to the exemptions and exceptions provided therein and in General Regulation 89 of 10th July, 1913,), shall be extended as follows in any seam newly opened, and in the further development of any seam already opened unless in the latter case the anticipated length of life of that part of the mine or the number of men to be employed does not justify the provision of two main-intake airways.

2. For each part of the mine having a main transport system serving more than one ventilating district, two main trunk intake airways (which shall be of such size and shall be maintained in such conditions as to afford a ready means of ingress and egress) shall be provided from the entrance to the seam (except within the distances from the shaft or outlet fixed in General Regulation 90 of the 10th July, 1913,) to the point where the last split is taken to ventilate any district of the mine :

Provided that :—

(i) two main trunk intake airways as aforesaid shall not be required if the number of persons employed below ground on any one shift in that part of the mine does not exceed 100 ;

(ii) in the case of a seam entered by a cross-measure drift from the surface or from the shaft bottom or from another seam, the " entrance " to the seam shall be the point where the cross-measure drift strikes the seam ;

(iii) two main trunk intake airways as aforesaid shall not be required in the case of drivage through old workings or goaf existing at the date of this directive.

3. In respect of each ventilating district where any working face is more than 1,000 yards from the main transport system, and where an inflammable belt conveyor exceeding 250 yards in length (other than a face conveyor) is installed ; the two main-intake airways shall be extended to the working face :

Provided that this requirement shall not apply :—

(i) if the number of persons employed below ground in that district on any shift does not exceed 50 ;

(ii) in the case of drivage through old workings or goaf existing at the date of this directive.

4. Where part of the workings in a seam is connected to workings in another part of the same seam by means of cross-measure drifts, owing to faults or other natural disturbances in the strata, the two intake airways need not be provided through or beyond the cross-measure drifts if they are not justified for the reasons given in paragraph 1.

5. This directive shall take effect forthwith in respect of newly-opened seams and on the 1st January, 1952, in respect of further development of any seam already opened.

Appendix IV

PROGRAMME OF INVESTIGATION WORK ON FIRE HAZARDS AT MINES

Subject	Sub-Heading	Primary Agency	Division of Activity			
			Field Investigation	Management and Organization	Engineering and Manufacturers	Research
A. *Qualitative and Statistical Analysis of incidents involving fire*	This is of great importance in determining where the hazards lie, so that projects can be precisely stated and priorities allocated.	Jointly by N.C.B. and Ministry	×			×
B. *Origin and spread of fires*	1. Sources of ignition—fundamental studies. A traditional S.M.R.E. field. Work on the ignition of coal dust by hot surfaces has been suggested.	Ministry				×
	2. The detection of heatings and a study of their development.	Ministry			×	×
	3. Temperature of ignition of different kinds of coal.	N.C.B. Scientific Dept.				×
	4. Travel of fires. Involves comprehensive investigation under realistic conditions in an experimental mine or gallery.	Ministry				×
	5. Special fire hazards in operating diesel locomotives.	N.C.B. Production and Ministry		×	×	
C. *Underground Communications*	1. Warning systems. Includes warning personnel of an emergency and indicating what steps should be taken.	N.C.B. Production	×	×		×
	2. Siting of telephones and exchanges. This would include a study of the adequacy of underground telephone systems.	N.C.B. Production	×	×		
	3. Patrolling. For example of conveyor belt installations.	N.C.B. Production	×	×		
	4. Development of new methods of U/G. communication. Orthodox radio systems unsatisfactory, but there is scope for further work.	N.C.B. Scientific			×	×

Subject	Sub-Heading	Primary Agency	Division of Activity: Field Investigation	Division of Activity: Management and Organization	Division of Activity: Engineering and Manufacturers	Division of Activity: Research
D. Automatic Devices	1. To operate warning devices and fire-fighting equipment such as sprinklers.	Ministry and N.C.B.	in collaboration with inspectorate		×	×
	2. Fire and Heat detectors. Smoke, gas, heat and flame actuated.	Scientific			×	×
	3. To operate plant. Switching off the power, controlling compressed air, etc.	N.C.B. Production			×	×
	4. Sequence control of multiple conveyor systems.	N.C.B. Production		×	×	
	5. Dust removers. Includes vacuum methods.	N.C.B. Production and Scientific			×	×
E. Fire Fighting	1. Fire drills. Design of drills and institution of regular practices.	Jointly by N.C.B. and Ministry Rescue Advisory Committees who should be directed to produce a programme indicating work needing to be done and suggesting appropriate agencies. (*Note.*—The Rescue Committee may need strengthening for this work.	×	×		
	2. Use of present fire-fighting equipment.		×	×	×	
	3. Development of new equipment.				×	×
	4. Standardisation of equipment.		×		×	
	5. Testing and maintenance of equipment.			×	×	
	6. Extinguishing agents: water, foam, etc.					×
F. Rescue	1. Rescue apparatus. Including breathing apparatus for rescue teams.		×	×	×	×
	2. Self-rescuers. For use by personnel other than rescue men.			×	×	×
	3. Rescue drills and methods.		×	×		
G. Fire Proofing	1. Conveyor belting. Use of neoprene, fire-proofed duck, etc.	N.C.B. Scientific	×		×	×
	2. Timber.	Ministry				×
	3. Lubricants.	N.C.B. Scientific			×	×
	4. Brattice Cloth.	Ministry				×

Appendix IV—Continued

Subject	Sub-Heading	Primary Agency	Division of Activity: Field Investigation	Division of Activity: Management and Organization	Division of Activity: Engineering and Manufacturers	Division of Activity: Research
G. Fire Proofing —(Cont.)	5. Cables.	N.C.B. Scientific and Inspectorate			×	×
	6. Paints and Varnishes.	N.C.B. Scientific			×	×
	7. Standard tests for fire-proofness. To avoid a multiplicity of empirical tests.	N.C.B. Scientific				×
	8. Noxious gases arising from fires and fire-proofing measures.	Ministry and N.C.B. Scientific				×
H. Preventative Measures on Equipment	1. Use of hoods. Advisability or otherwise, and design.	N.C.B. Production and Inspectorate		×	×	
	2. Conveyor rollers. For instance, use of self-lubricators.				×	×
	3. Rubber-lined driving pulleys.				×	×
	4. Belt jointing and stitching. Refers to the relative safety and mechanical efficiency of vulcanising versus metal joints and stitching.				×	
	5. Belt maintenance generally.		×	×	×	
	6. Conveyor chutes.				×	
	7. Auxiliary driving belts.				×	
	8. Use of open type conveyor structure.			×	×	
	9. Width and speed of belts.			×	×	
	10. Means for preventing overloading of belts.			×	×	
I. Colliery Layout	1. Intake airways on trunk conveyor systems. The question of number and connections between intakes.	N.C.B. jointly with the Ministry (Inspectorate)		×		
	2. Location of conveyors whether intake or return.			×		
	3. Installing of conveyors.			×		
	4. Use of alternative haulage methods.	N.C.B. Production	×	×		
	5. Water supply, quantity, quality, pressure.	N.C.B. Production and Inspectorate		×	×	

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