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FINAL REPORT OF MINE EXPLOSION
NO. 3 MINE, CHRISTOPHER COAL COMPANY
OSAGE, MONONGALIA COUNTY, W. VA.
MAY 12, 1942

By

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

CONTENTS

CONTENTS (Cont'd)

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INTRODUCTION

A gas and dust explosion occurred in the No. 3 mine of the Christopher Coal Company at about 2:25 p.m. on May 12, 1942.

There were 117 men in the working sections of the mine at the time of the explosion and 107 men were on an inbound mantrip about 3,000 feet from the mine portal.

The explosion was local in character, having been confined almost entirely to the portion of the mine in which it originated. Fifty-six men were killed in the explosion. Of this number, 53 men were killed in the explosion area by violence, burns, and afterdamp, and three others were killed by afterdamp outside of the explosion area, along the main haulage road.

Some of the survivors working in an unaffected portion of the mine made an effort to errect a barricade but this effort was abandoned and the survivors reached the fresh air by traveling the return air courses parallel to the left of the main haulage road.

The explosion was caused by the ignition of a body of methane by means of an electric arc inside the contactor box of a cutting machine and was propagated throughout the affected portion of the mine by gas and coal dust.

The Pittsburgh office of the Bureau of Mines received a report of the explosion at 3:45 p.m., May 12, 1942. A Federal mine inspector, located at Morgantown, W. Va., was immediately reached by telephone and directed to investigate and to advise the Pittsburgh office as soon as he had obtained confirmation of the report. When this inspector reported back that there had been an explosion of undetermined extent, a crew of engineers and inspectors, from the Pittsburgh station of the Bureau of Mines, were immediately ordered to the scene of the disaster by Mr. J. J. Forbes, Chief of the Coal Mine Inspection Division.

The first Federal inspector to reach the scene was Mr. A. K. Bloom of Morgantown, W. Va., who arrived at the mine at 5:15 p.m. and entered shortly thereafter in company with State mine inspectors P. J. McGraw and M. G. Dobbie. Mr. F. E. Griffith, of the Bureau of Mines, arrived at the mine at 6:30 p.m. and the party from Pittsburgh, consisting of Messrs. J. W. Pero, R. W. Stahl, and W. W. Kessler, arrived at 7:30 p.m. Messrs. H.H. Kazeand J. R. Dukes, also of the Bureau of Mines, arrived at 8:30 p.m. with the Bureau of Mines mine-rescue truck. Another Federal inspector from Fairmont, W. Va., arrived at 6:00 p.m.

These Bureau of Mines representatives participated actively in the recovery operations underground and in perfecting a surface organization to supplement the underground work. Close cooperation existed between the representatives of the Federal Bureau of Mines and the West Virginia Department of Mines in directing the recovery operations. Federal inspectors, together with State inspectors, remained on duty at the mine until 12:00 m, May 23, when the last body was brought out of the mine.

GENERAL INFORMATION

Location and Operating Officials

The No. 3 mine of the Christopher Coal Company is located at Osage, Monongalia County, W. Va., on the Scotts Run branch of the Monongahela Railroad. This mine is affiliated with the No. 2 mine, Christopher Mining Corporation, Maidsville, W. Va.; the Brock No. 4 mine, Brock Incorporated, Cassville, W. Va.; the National No. 5 mine, Christopher-National Mining Company, Flickersville, W. Va.; and the Lincoln Mine, Christopher Mining Company of Pennsylvania, Lincoln Hill, Pa.

The officials of the company are:

Frank E. Christopher	President	Morgantown, W. Va.
Lee Christopher	Vice President	Morgantown, W. Va.
James M. Hill	Chief Engineer	Morgantown, W. Va.
Edward H. O'Neil	Mine Superintendent	Osage, W. Va.
C. P. Pride	Safety Director	Morgantown, W. Va.
Howard Feathers	Mine Foreman	Osage, W. Va.

Employees and Production

Four hundred and fifty-seven men were employed at this mine. Of this number, 119 were employed at the surface plant and 338 were employed underground.

The underground employees were divided by shifts as follows: day shift, 124; afternoon shift, 107; night shift, 107. The average daily production was 5,000 tons, with a maximum daily production of 5,800 tons. The total production for the year 1941 was 1,289,698 tons of coal.

Openings

The mine is opened by a single drift entry, driven through the old workings of the Osage mine of the Brady-Warner Coal Company, and by two airshafts.

The first shaft, which serves as an intake airway and escapeway, is located about 5,700 feet from the mine portal. This shaft is a circular opening, 12 feet in diameter and 144 feet deep, partially lined with concrete, and is provided with a steel ladder having circular, steel back guards.

The second shaft, which serves as an upcast airway, is located 9,500 feet from the portal and about 9,700 feet from the innermost active workings. This is a single-compartment, concrete-lined, circular shaft, 12 feet in diameter and 278 feet deep.

Nature of the Coal Bed

The mine is developed in the Pittsburgh coal bed, having an average thickness of 95 inches in this locality.

A bench of about 75 inches of the coal is mined and a layer of head coal, of inferior quality, from 18 to 24 inches thick, is left in place to form the roof.

The coal is of bituminous rank, of bright appearance, hard in structure, and has pronounced face- and butt-cleavage planes. This coal bed contains the characteristic bands of bony coal usually found in the Pittsburgh bed. The coal is underlain by a bed of hard shale.

Above the head coal is a layer of draw slate, ranging in thickness from 12 to 36 inches; and this draw slate, together with the head coal, forms the immediate roof of the mine. Above the draw slate is a layer of gray, sandy shale (about 40 feet in thickness) and from this, up to the Sewickley coal bed, a distance of about 70 to 90 feet, are numerous layers of limestone and shale.

The cover over the coal ranges from 0 to about 350 feet.

Analysis of Coal

A face sample of coal was collected by the Bureau of Mines in the nearby Eureka mine, operated in the same coal bed, on October 17, 1924, and this was analyzed in the coal laboratory of the Bureau of Mines at Pittsburgh, Pa. The coal, which is representative of the Pittsburgh coal bed in this locality, contained .8 percent moisture, 37.3 percent volatile matter, 52.5 percent fixed carbon, 9.4 percent ash, and 3.1 percent sulfur.

The ratio of the volatile matter to total combustible matter of the coal, expressed by the formula

$$\frac{\text{volatile matter}}{\text{volatile matter + fixed carbon}}$$

is an index to the explosibility of the coal. This ratio is:

$$\frac{37.3}{37.3 + 52.5} = 0.42$$

Bureau of Mines tests and experiments have shown that coal dust having a volatile matter to total combustible matter ratio in excess of 0.12 is explosive. The explosibility of coal dust increases as this ratio increases. It is obvious, therefore, that the coal dust in this mine is highly explosive and would readily propagate an explosion.

UNDERGROUND MINING METHODS, CONDITIONS, AND EQUIPMENT

Methods of Mining

The haulage tunnel is connected to the surface by two short drifts. The short drifts converge about 100 feet inby the portals to form the one main tunnel. This tunnel was driven through the old pillars and gob areas of the Osage mine to the property line of the present mining area.

When the haulage tunnel reached the solid coal at the extreme inby edge of the Osage mine, a series of 16 main entries was driven in a westerly direction to the property line. The 16 main entries were developed in sets of four, with a barrier pillar between each set. The barriers are continuous, except for haulageway openings at about 550-foot intervals.

The limited number of openings through the separating barriers facilitates isolation of the entries for ventilation purposes.

Flat entries are driven from the main entries at irregular intervals. The flat entries are driven four abreast on 80-foot centers. The barrier between the two center entries is cut through at 180-foot intervals.

Producing entries are turned from the flat entries and are driven to the pillared areas of the adjacent flat entries. Each section consists of a set of four entries driven on 90-foot centers. A 76-foot barrier is left between each section. Crosscuts are turned at 60 degrees and driven on 80-foot centers between all four entries in each section. All entries and crosscuts are driven about 15 feet wide.

Each section, or set of four entries, provides working places for a complete mechanical unit, including a cutting machine, loading machine, drill, and locomotive. Usually four to six working places are maintained in each section. Each section comprises an independent unit which is supervised by a face boss or section foreman.

When the section is developed to the adjacent gob area, pillar extraction is started immediately and the barrier between the entries of each section is recovered on the retreat. The pillars are recovered by the split-and-fender method. The fenders are recovered unless the roof becomes too heavy for safe extraction.

Where pillar breaks are maintained along a definite line, excess roof pressure is not presumably encountered. At the present time, however, the main entry section, inby 3 left, shows considerable weight because a definite fracture line has not been maintained.

In the 1-1/2 right area, which involves three working sections at the present time, the No. 3 section is lagging behind the No. 2 section and a definite break line is not maintained. A plan whereby all development and pillar extraction is controlled is not in use at the mine. The advance and retreat of the panels is controlled by local supervision and no periodic check is made to determine the progress of the mining operations.

The maintenance of a definite fracture line also has a decided bearing on the control of gas from the proper ventilation of gob areas adjoining the active working places. Where one section lags behind, as in the case of No. 3 section, 1-1/2 right area, the air current cannot be properly coursed along the pillar line but must be deflected into working places in its travel from one section to the other.

The coal is top cut, undercut, and sheared on both sides in the main entries, leaving a nearly rectangular entry. In flat entries, panel entries, and crosscuts the coal is undercut twice, forming a wedge-shaped kerf about 14 inches high at the front and 7 inches at the back of the cut. All cutting is done with Sullivan and Jeffrey Universal, track-mounted mining machines. The coal is drilled with Jeffrey hand-held drills which receive power from the power cables of the cutting machines. Four holes are used to blast each cut of coal, three holes are placed near the top and one hole about 2 feet below the center top hole. The bottom hole is blasted first and serves as a breaker shot.

The mine is completely mechanized and all coal is loaded by Goodman loading machines.

The strata overlaying the bed is characteristic of the geologic formations in this vicinity. From 12 to 24 inches of coal is left in place to support the overlying draw slate. Immediately above the coal bed there is from 12 to 36 inches of draw slate, which contains a thin coal bed inclusion in most sections of the mine. The draw slate is overlain by low quality limestone. The mine floor is composed of hard shale, which apparently is not affected by moisture and presents a smooth surface when exposed.

Entries and crosscuts are generally timbered with wooden crossbars, supported by wooden posts. The roof is well supported except at intersections. The crossbars are placed at intervals of from 3 to 5 feet.

A continuous clearance of 30 inches is not maintained on the walkway side of entries and this is especially true along the main haulageway where the clearance ranges from 3 to more than 30 inches.

Shelter holes are not maintained at regular intervals along the haulageways. Some of the shelter holes are obstructed with timber and refuse.

Ventilation and Gas

This mine is ventilated by a 7-foot Jeffrey Aerodyne fan, exhausting about 135,880 cubic feet of air per minute against a water-gage pressure of 2.2 inches.

The fan is connected to the airshaft by a steel duct. The fan housing and motor house are constructed of sheet steel. The fan is offset about 10 feet from the shaft. A weak wall or pressure-relief door has been incorporated in the fan duct but is not effective because steel bolts are used to fasten the wall in place.

The fan is not readily reversible and there is no separate source of power provided. A spare motor is kept in a shop some distance from the mine. Power is supplied direct from a nearby substation and the fan circuit is independent of the mine circuit.

No warning device has been installed to indicate when or if the fan slows down or stops. The fan is not constantly attended.

A map of the mine, included in this report in appendix "A," has indicated on it by arrows the direction of the air through the mine, prior to the explosion. The intake air enters the mine through the main haulage tunnel and the intake airshaft, then is conducted through the eight center entries to the working sections. The return air from the right side of the mine is conducted to the return shaft through the four extreme right entries, while the return from the left side is coursed through the four extreme left entries to the upcast shaft.

The entire mine is ventilated by six air splits as follows:

No. 1 split ventilates Nos. 1, 2, and 3 sections, 1-1/2 right.
No. 2 split ventilates face of 1-1/2 right and pump.
No. 3 split ventilates main entries and pump near face of main entries.
No. 4 split ventilates inby portion of 3 left area.
No. 5 split ventilates outby portion of 3 left area.
No. 6 split ventilates 2 left area.

The intake air entering the mine through the haulageway and the intake shaft passes through abandoned workings before entering the intake airways in the new development.

The main intake air current is split at 1-1/2 right, where approximately half of the total volume enters the 1-1/2 right section; and the remaining portion is conducted inby, then split, with one portion being coursed through 2 left and the remainder conducted to 3 left where a portion ventilates the main entries and a pump. This split returns over the 1-1/2 right overcast.

Another split is conducted into 3 left, where the volume is again split, with one part ventilating the outby workings of 3 left and the other ventilating the inby portions of 3 left. The return from 3 left joins the return from 2 left and is coursed through the main return to the upcast shaft.

The air entering 1-1/2 right area is split at No. 3 left and one portion is coursed through No. 3 section; thence through No. 2 and No. 1 sections and joins the return from the main entries at the 1-1/2 right overcast. The remainder of the air is coursed through the face area of 1-1/2 right and is returned, through the right parallels of 1-1/2 right, to the main return airways. The return air from the three sections and from the main entries passes over the overcast and joins the return air from the face area of 1-1/2 right and the entire volume is conducted to the upcast shaft.

The intake air entering the 1-1/2 right area, where the explosion occurred, is conducted by means of concrete-block stoppings to the working sections. The concrete-block stoppings are built between the haulageway and the right parallel airways from the intersection of the main return airways and 1-1/2 right haulageway to a point just inby No. 4 section. From this point to the pump on 1-1/2 right, wooden and brattice-cloth stoppings are used to course the air current.

Single doors are installed at the entrance to each section, except the No. 1 section, where two doors were required because an entry was turned left from the No. 1 section haulageway. This condition necessitated the building of a door in the left entry and one in the haulage road just inby this intersection. These doors did not form an air lock.

The air is coursed through the working sections by means of wooden stoppings; wooden doors, erected singly; and brattice-cloth stoppings and curtains. Incombustible stoppings were not used in the working sections off 1-1/2 right.

Regulators are constructed of wood and concrete blocks. A sliding wooden door is placed in a concrete-block stopping. The sliding door may be readily adjusted to permit the passage of the desired quantity of air.

Overcasts are constructed with concrete-block walls and combination wood-steel-and-cement mortar tops. Steel rails are placed across the walls and the space between the web of the rails is filled with wooden blocks. The space from the top of the wooden blocks to the top of the rail is filled with cement mortar and all cracks and crevices are plastered.

The door at the entrance to the No. 3 section is left open and the main air volume is split at this point, one part entering 3 left and the other portion ventilating the pump on 1-1/2 right. The air is conducted to the faces of No. 3 section, through the working places, and then to the No. 2 section. The air is then coursed through No. 2 section along the pillar line to No. 1 section. After being coursed through the active working places in the No. 1 section, the return air is conducted to the main return airways and then to the upcast shaft.

Since only single doors are erected at the entrance to each section, anytime a door is left open the air current is short-circuited and all sections inby the door receive no ventilation. If the door at No. 2 section were left open, No. 3 section would receive no air. Similarly, if the door on the main haulage road of the No. 1 section were left open, the air would be short-circuited from Nos. 2 and 3 sections but the No. 1 section would be ventilated. If the door in the left entry of the No. 1 section were left open, the air would be completely short-circuited from all three sections and would short-circuit directly to the main return airways.

Doors are equipped with latches for holding them open and evidence gathered during the investigation indicates that the door on the straight entry of the No. 1 section was open when the explosion occurred.

The mine is rated as gassy by the West Virginia Department of Mines. Fire bosses are not employed. The assistant foreman make a fire-boss examination of the entire mine each Sunday, just before the midnight shift enters the mine. The mine is operated triple shift, 6 days per week. The beginning of the work week is Sunday at midnight and the end of the week is Saturday at midnight. During the week, the assistant mine foreman in each area examines all working places in his area, near the end of his shift, reports the result of his examination to the succeeding assistant foreman and records his findings in a report book. The report books are kept in the foremen's stations on the working areas. The mine foreman reads and countersigns each report book daily.

It is reported by the management that frequent tests for gas are made along the pillar lines in working places and on top of pillar falls by mine officials and inspectors and that no accumulations of gas on the 1-1/2 right pillar line have ever been reported. It was reported that explosive gas had been detected several times in the adjacent worked-out area, to which the explosion area is connected.

Explosive gas was detected on pillar falls in the affected area during the investigation and concentrations of explosive gas were found 300 feet outby the face of the extreme left entry of No. 3 section while the recovery operations were in progress. This was prior to the restoration of normal ventilation and about 72 hours after the explosion.

Air samples, taken during the investigation and after normal ventilation was restored, are shown in table 1. The sampling locations are shown on the map of the mine, appendix "A."

Samples Nos. 900, 899, and 895; taken at the fan soon after the explosion on May 12; contained 0.15, 0.08, and 0.09 percent methane respectively. The carbon-monoxide content of these samples ranged from 0.07 to 0.14 percent. These samples contained less methane than those taken by the company safety director during the normal operation of the mine. The normal methane content of the main returns, as reported by the company on May 8, was 0.20 and 0.25 percent respectively.

Sample No. 992 was taken on May 15, on a pillar fall in a cut-through in the barrier pillar between No. 2 and No. 3 sections. This place had been cut through to the caved area of the No. 2 section, as the No. 3 section was developed. The analysis shows that explosive concentrations of gas (5.54 percent) were present on the edge of the pillar falls at this time.

The analyses of samples of the return air splits from the explosion area, taken on May 20 while the mine was still idle, show the presence of 0.12 percent of methane in the air currents in both splits. A total of 46,656 cubic feet of methane was being liberated every 24 hours from the working places and adjacent pillar falls in the three sections of 1-1/2 right at that time. Another sample of return air from the face regions of the 1-1/2 right area, taken near the regulator, shows that 25,523 cubic feet of methane is liberated from this temporarily abandoned area inby the No. 3 section every 24 hours. These samples and air volumes were taken during the investigation, while the mine was idle. These data substantiate the evidence previously gathered concerning the liberation of gas from gob areas.

Numerous tests of face areas were made with a W-8, permissible methane detector during the investigation and only small percentages (0.05 to 0.10 percent) of explosive gas were found. This indicates that the greater part of the explosive gas present in the return air currents is being liberated from the pillar falls and gob areas.

Samples of return air from splits in the affected area and of the main returns at the bottom of the upcast shaft were taken on Tuesday, May 26, 1942, after the mine had resumed operations and worked four shifts. These samples are considered representative of the normal mine atmosphere, since the mine had resumed operations 26 hours previous to the time that the samples were collected.

Sample No. 604, taken near the gob area in the No. 1 section of 1-1/2 right, shows 0.31 percent methane in 5,580 cubic feet of air per minute. This sample provides additional evidence that gas is being liberated from pillar fills and gob areas in the explosion area.

Sample No. 1,000 was taken in the last open crosscut, where the total volume of return air from Nos. 1, 2, and 3 sections, 1-1/2 right, passes on its way to the main return airways. This sample contained 0.09 percent methane in 33,465 cubic feet of air per minute. This further supports the belief that the major portion of the gas liberated in this section comes from gob areas and pillar falls.

Sample No. 995, taken near the overcast, representative of all of the return air from the left side of the 1-1/2 right area, plus the return from the 2 and 3 right areas, contained 0.31 percent of methane in 54,808 cubic feet of air per minute; accordingly these areas were liberating 244,663 cubic feet of methane every 24 hours.

A sample (No. 999) taken at the regulator of 1-1/2 right, shows 0.21 percent methane in 8,255 cubic feet of air per minute. Since there are no active working places in this area, the methane must have been liberated from solid coal and gob areas near the face of 1-1/2 right.

Duplicate samples taken near the bottom of the return shaft show that the right side of the mine contained 0.31 percent methane in 75,400 cubic feet of air per minute, or that 336,585.6 cubic feet of methane was liberated every 24 hours; and the left side of the mine contained 0.18 percent of methane in 60,480 cubic feet of air per minute; or 156,764 cubic feet of methane every 24 hours. The entire mine, therefore, was liberating 498,778 cubic feet of methane every 24 hours. It is concluded from these analyses that explosive gas is being liberated in large quantities and that a dangerous condition could result should the ventilation be short-circuited, or otherwise interrupted, even for a short period of time.

TABLE 1. - Analyses of air samples collected in No. 3 mine
Christopher Coal Company
Osage, Monongalia County, West Virginia

Bottle No.	Date	Location in mine	Percent Carbon dioxide	Oxygen	Carbon monoxide	Methane	Nitrogen	Cubic feet air per minute	Cubic feet methane in 24 hours
900	5/12/42	Return air at fan	0.30	20.23	0.14	0.15	79.11		
899	do.	do.	0.23	20.47	0.10	0.08	79.08		
895	do.	do.	0.17	20.51	0.07	0.09	79.12		
992	5/15/42	Sta. 4159 + 60 ft. (on pillar fall)	0.52	18.19		5.54	75.75		
602	5/20/42	Return left side 1-1/2 rt. section off No. 1 heading No. 1 section	0.14	20.57		0.12	79.17	27,000	46,656
603	5/20/42	Return rt. side 1-1/2 rt. section at regulator	0.16	20.65		0.12	79.07	14,770	25,522.56
604	5/26/42	Gob return from 1,2,3, section 1-1/2 right, 30 ft. left at Sta. 4037	0.19	20.45		0.31	79.05	5,580	24,909.12
995	do.	Return 1,2,3, sections 1-1/2 rt., 2 rt. and 3 rt. at overcast, 30 ft. inby Station 1298	0.18	20.44		0.31	79.07	54,808	244,662.91
999	do.	Return right side 1-1/2 rt. at regulator	0.09	20.59		0.21	79.11	8,255	24,963.12
1000	do.	Return 1,2,3 sections 1-1/2 rt. in crosscut 45 ft. to left of Station 4021	0.13	20.59		0.09	79.19	33,465	43,370.64
601	do.	Return rt. side of mine, 15 ft. from bottom of shaft	0.21	20.41		0.31	79.07	75,400	336,585.6
606	do.	do.	0.21	20.37		0.32	79.10	75,400	347,443.2
608	do.	Return left side of mine 60 ft. from bottom of shaft	0.15	20.37		0.18	79.30	60,480	156,764.16
998	do.	do.	0.16	20.41		0.18	79.25	60,480	156,764.16

Haulage

The track gage is 42 inches and 85-pound rails, braze-welded at the rail joints, are used on main and secondary haulage. Forty-pound rails are used in the rooms and entries in the face regions.

Proper clearance is not maintained along the haulage road in the old section of the mine, where the clearance varies from 3 to 24 inches. In the new development, clearance of at least 24 inches is maintained on the wide side of all entries and at least 18 inches on the trolley-wire side. Shelter holes are provided, by means of crosscuts driven at 78-foot intervals along the haulage-ways and entries, but material and supplies were stored in these crosscuts generally throughout the mine.

Steel mine cars of 10-ton capacity, equipped with automatic couplings and closed floors and ends, are used.

Electric trolley locomotives, of 10-, 13-, and 15-ton capacity, provide motive power on the main haulageway; and 4-, 6-, and 8-ton combination cable-reel-and-trolley locomotives are used for gathering.

All main haulage is on intake air.

Trolley wires are provided with rubber guards at locations where men are required to work or pass under them.

Mine cars have automatic couplings and are not provided with bumpers. Transportation men ride on a demountable seat attached to the rear end of trips, or on stirrups attached to the rear end of the cars, immediately over the automatic coupling.

Haulage is controlled by a dispatcher. The dispatcher station is located underground near the working areas.

Lighting

Incandescent electric lights provide illumination at run-away latches, dispatcher and foremen's underground offices, junctions, and storage tracks. These lights are attached to the trolley wire and are not guarded or fused. Portable electric lights, of the Ceag type and 14 in number, are used for trip lights.

Ten Koehler and twenty Wolf permissible flame safety lamps are used by the foremen and facebosses for gas-testing purposes. Three hundred and forty permissible, Model "P" Edison electric cap lamps are used by all underground employees for illumination.

Machinery Underground

All underground electrical equipment is operated on 275 volts direct current. The power is purchased from the West Penn Power Company at 2,300 volts alternating current and is transformed and converted to 275 volts direct current for use in the mine. Three substations, located at convenient places on the surface, are used to convert the alternating current to direct current. The power cables, not enclosed in conduit, are taken into the mine through boreholes. The "live" cables are insulated but the return cables are bare. Both circuits are enclosed in the borehole casing. The power cables are led through a knife-blade switch to the feeder cables and the return circuit is welded to the track near the bottom of the borehole.

The coal-cutting equipment consists of two 29-U Jeffrey Universal, track-mounted and five 7-A-U Sullivan Universal track-mounted, permissible cutting machines. The cutting-machine trailing cables are connected to the power source by fused nips and to the return circuit by hook nips. A continuous return circuit is maintained and is connected to the track at intervals. The connection is usually made by fastening the cable to the rail with a track spike or by other nails driven into the tie to hold the wire against the rail. These connections are not usually secure and arcing is evident at the loose return connections.

The mining equipment in the explosion area was examined carefully, during the investigation, by Mr. G. F. Newman, Associate Coal Mine Inspector of the Coal Mine Inspection Division of the Bureau of Mines. The following nonpermissible conditions were observed on equipment in the affected area:

Sullivan 7-AU mining machine (Company No. 6) located in crosscut off No. 2 entry, No. 1 section, 1-1/2 right:

1. An oversize (400 amperes) fuse in trailing cable nip.
2. Two headlight covers not locked or sealed.
3. One cap screw missing from resistor box cover.

Sullivan 7-AU mining machine (Company No. 8) located in No. 2 section 1-1/2 right:

1. An oversize (400 a.) fuse in trailing cable nip.
2. Headlight covers not sealed or locked.
3. Two cap screws missing from contactor box cover.
4. Eight cap screws missing from resistor box cover.

Sullivan 7-AU mining machine (Company No. 5) located in No. 3 section, 1-1/2 right:

1. Three cap screws missing from contactor box cover.
2. Control circuit in contactor box bridged with wire.
3. Reset lever removed from contactor box, leaving an opening into the box. A cable was led from the remote-control buttons across the

top of the machine, through the opening in the contactor box to the control circuit. This opening was sufficiently large to permit flame to escape from the contactor box.

4. Two cables inside the contactor box (a resistor lead, and shunt and series field lead) had contacted and caused a short-circuit. The insulation was burned from both leads for a distance of 3 inches. The cables showed evidence of intense heat and burning at the exposed area.

The wiring within the contactor box had evidently ignited at some previous time and there was evidence that rock dust had been used in extinguishing the fire. The contactors and inside of the case were coated with rock dust. A sample of coal dust, taken from the box, contained numerous particles of coke.

Coal-loading equipment consists of six Goodman-460 and two Goodman-360, track-mounted, permissible-type loading machines. The trailing cables of the loading machines are connected to the trolley circuit by fused nips and to the return circuit by hooked nips.

A careful examination of the loading machines by Mr. C. F. Newman, revealed the following nonpermissible conditions:

Goodman-460 loading machine (Company No. 8) located in No. 1 section, 1-1/2 right:

1. Trailing cable not provided with fused nip.
2. Headlight covers not sealed or locked.
3. Broken lens on light on right side of discharge conveyor.
4. Screw-type inspection covers missing from discharge conveyor motor.
5. Contactor box not locked.
6. Discharge-conveyor controller box not locked.
7. Headlight circuit fuses removed and circuit bridged with No. 14 copper wire.
8. Fuses removed from discharge-conveyor motor circuit and terminals connected.
9. Main control circuit in the contactor box bridged with No. 14 copper wire.
10. Cap screw broken in cover of switch box.

Goodman loading machine (Company No. 6) located in No. 2 section 1-1/2 right:

1. Headlight covers not locked or sealed.
2. Protecting hose removed from headlight circuit on left side of machine.
3. Packing glands missing from both headlights on discharge conveyor.

4. Two cap screws missing from resistor box cover of 4 hp. motor.
5. Inspection cover plates missing from discharge-conveyor motor
6. Lock missing from the 4 hp. motor controller box.
7. Fuses had been removed from the main control circuit and the terminals of the leads connected together.
8. Headlight circuit bridged with No. 14 copper wire.
9. Three cap screws missing from the switch-box cover
10. Fuse in trailing cable was bridged.

Goodman loading machine (Company No. 7) located in No. 3 section:

1. Headlight cover missing from the headlight on the right side of discharge conveyor.
2. Packing gland missing from same headlight.
3. Main motor contactor box not locked.
4. Discharge conveyor controlled box not locked.
5. An oversize (400 a.) fuse used in cable nip.

The coal drilling equipment consists of eight A-7 Jeffrey hand-held drills. The drills are connected to the power and return circuit of the mining machines inside the contactor box in such a manner that power is transmitted to the drill motor when the trailing-cable nips of the machine are attached to the power circuit. The only power control switch in connection with the drill assembly is the drill operating switch.

Two drills were examined by Mr. G. F. Newman and the following nonpermissible conditions observed:

Jeffrey A-7 hand-held coal drill, located in No. 1 section 1-1/2 right:

1. Motor and switch-cover plates were not sealed.
2. The fuse on the drill motor was bridged.
3. The switch housing was broken and had been patched.

Jeffrey A-7 hand-held coal drill, located in No. 2 section, 1-1/2 right:

1. The fuse on the drill motor was bridged with No. 14 copper wire.
2. The motor and switch-cover plates were not sealed.

The Jeffrey A-7, hand-held drill used in the No. 3 section, was sent to the Bureau of Mines laboratory at Pittsburgh for ignition test in explosive atmospheres. When the drill was checked before the test, it was found that the switch had been shunted out and a hole had been burned through the side of the switch housing. When the drill was operated in an explosive mixture of gas at the laboratory, it did not ignite gas. Eleven separate tests were made at the laboratory and, although flame was observed issuing from the aperture in the cover, gas was not ignited. This does not prove, however, that gas could not be ignited by this drill or any other drill in a similar nonpermissible condition.

The pumping equipment consists of four centrifugal and one plunger-type pumps. The pumps are generally installed along the entries in intake air, although the intake air passes abandoned areas before reaching the pump installations.

It was observed that the Scranton, 1,000 g.p.m., 80-foot head, centrifugal pump, located on the main entry near the face of 1-1/2 right entry, was operated by an open-type, direct current, electric motor, and an open-type contactor starter. The power circuit leading to the pump motor was bridged with wire and the starting resistance was bridged through coils suspended on a wooden post near the starter assembly. The switch and starter boxes are not kept closed. Insulating mats are not provided at the pump control switches.

Trolley wires are installed in the crosscuts of the working sections and are usually terminated just outby the last open cut-throughs. The ends of the trolley wires are secured by insulated turnbuckles but are not guarded.

Trailing cables of mining and loading machines are connected to the trolley wire by fused nips, usually just outby the last open cut-through. Oversize fuses are generally used in the nips.

Trolley wires are suspended from insulated hangers along the entries and in face areas are usually 5 feet or more above the rail, but are not always kept 6 inches or more outside the rail. The trolley wires in the affected area, especially in Nos. 1 and 2 sections, are in the return air from the No. 3 section.

The main-line track and flat-entry track are bonded, with welded bonds at all track joints, but cross bonds are not installed at regular intervals. The entry track in working sections is not bonded but a continuous return wire is installed on the ties beside one rail. The return wire is connected to the rail at intervals by track spikes or wire mails. These connections are not secure and arcing [illegible] at track joints and at contact between the return wire and the track.

The return circuit of cutting and loading machines is connected to unbonded track in face areas; thus arcs are often evident at track joints.

Lack of bonding in the face areas causes arcs and sparks when a loading-machine boom contacts an all-steel car during the loading operation. These imperfect return circuits, and the improper grounding of electrical equipment, are a constant source of arcs and sparks and constitute a potential gas and dust ignition hazard.

Cable-reel locomotives, with open-type resistance and open-type controllers, are operated in face areas on unbonded track. The locomotives receive power from a single-conductor trailing cable, consequently all return circuits are through unbonded track in face areas.

Temporary splices in cables are made inside the mine by machine operators. Ring-type splicers are used and the joints are insulated with friction tape. It was observed that cables contain numerous temporary splices. The cable on the cable-reel locomotive used in No. 1 section at the time of the explosion, contained 14 temporary splices in 200 feet of cable.

All underground equipment is inspected by the section mechanics during the shift but thorough inspection is not possible while the machines are in operation; consequently complete inspections are not made. Repair work is usually of a temporary nature.

Explosives and Blasting Practices

Shots are fired at any time during the shift by shot-firers. Men employed as shot-firers are not certified by the State, or any other agency, and they are not provided with flame safety lamps, nor required to test for gas before and after firing each shot.

Permissible, Liberty No. 9 explosives are used for blasting. The cartridges are 1-1/4- by 8-inch size and weigh about 4.1 ounces each.

The coal is blasted by firing four holes 2-1/2 inches in diameter and about 8-1/2 feet deep. Three holes are placed 10 inches from the roof and 6 feet apart, the middle one being in the center of the 14-foot wide face. A fourth hole is placed 2-1/2 feet to the right of, and 3 feet below, the center hole. The fourth hole is used as the break shot. The holes are drilled by the driller after the working places have been cut. An average of three cartridges (12.3 oz.) of explosives are used per hole. Rock dust, in prepared paper cartridges, is used for stemming.

The charges are fired by No. 6 electric detonators having 9-foot leg wires, which are kept shunted until ready to fire. Duplex cables are used by the shot-firer to fire the shots.

Shots are fired by inserting the ends of the blasting cable through holes drilled in the top of the electric-cap-lamp battery cases.

Explosives are said to be taken into the mine by the supply crew, on the midnight shift, in a wooden car hauled by a locomotive. It was stated that eighteen 50-pound boxes of explosives are distributed to the six metal storage boxes on the sections. Each box has a capacity of about 200 pounds.

The storage boxes are provided with locks and are kept in crosscuts about 200 feet from the working faces.

The detonators are reported to be taken into the mine in the same car with the oil, after the explosives have been delivered. About 400 detonators are taken into the mine, in the original containers, and distributed among the 6 wooden storage boxes on the sections. The storage boxes are provided with locks. It was stated that the detonator boxes were stored around the corner of the crosscut from the explosives.

The mine foreman and assistant mine foreman on each shift are provided with foremen's licenses to issue explosives. The face-bosses on each machine section have the keys to the boxes and are supposed to issue the explosives to the shot-firers. The three foremen and the supply man have master keys to all explosives boxes underground.

Drainage

The mine is comparatively damp, except in the working areas of 1-1/2 right. Small pools of water were observed along the main haulage roads and in the face areas of 3 left and the main-entry pillar section. Considerable water accumulates in the main-entry pillar section and in 3 left area but this is not a problem during the normal operation of the mine.

The most serious water problem is encountered at the face of 1-1/2 right entry when the main roof was broken during pillar extraction. The broken strata in this section permits water to drain from the Sewickley coal bed, which is being worked directly above this area. Water from a large area in the Sewickley coal bed drains into 1-1/2 right at this opening.

A 1,000-g.p.m., centrifugal pump is installed near the face of 1-1/2 right to pump the water to a ditch along the 1-1/2 right entry. The water is then conducted by ditches to a sump just outby 1-1/2 right intersection. Water from this sump is pumped to the surface through a borehole.

The water from the 3 left area and the main-entry pillar section is also pumped to the surface through a borehole.

The pumps are not operated continuously, since a considerable area is covered by the sumps and a large, shallow body of water may be impounded before the water overflows into active working areas.

An inspection of the return airway from the return shaft to the 1-1/2 right entry revealed the presence of numerous pools of water impounded by roof falls in the airways. This water, however, does not materially obstruct the passage of air through the airways. When the water rises to a predetermined level, it will drain to the sump near 1-1/2 right.

Water is also impounded by dams near the face of 1-1/2 right but will not enter the active sections of the area unless the pump is stopped for several days.

Small pools of water were observed along the 1-1/2 right haulage road and the right parallels of the same entry. Accumulations of water are present at the face of the inactive No. 4 section because of an overflow from the 1-1/2 right sump while the pump was temporarily stopped due to the explosion.

Coal Dust and Rock Dust

Considerable coal dust is "made" during the operations of cutting, drilling, blasting, and loading. Much of the fine coal dust produced by mining operations is picked up by the ventilating current and deposited on the ribs, timbers, and ledges. Water is not used to allay the coal dust but, since the explosion, water lines have been installed to each working face in the 1-1/2 right area. Sections of rubber hose are provided to wet down the dust during mining and blasting operations and to wet down the coal during loading. Coal dust in suspension increases the possibility of explosions to a great extent and materially decreases visibility; moreover, the prolonged breathing of dust-laden air impairs the efficiency of workmen and may be a distinct hazard to health.

Quantities of dust and coal are allowed to accumulate along the ribs of the working places. This condition should be corrected because it decreases the available clearance and requires larger quantities of rock dust to be applied to render the coal dust inert.

The rock-dusting practices in this mine have not been thorough enough to afford any protection against the propagation of a coal-dust explosion. A low-pressure rock-dusting machine, for use interchangeably between this and another mine, was used to apply rock dust on haulage entries on alternate week ends. The haulage roads, therefore, appear to have been fairly well rock-dusted but no effort has apparently been made to introduce rock dust into trackless entries and return airways, of which there are many.

There is evidence that sporadic rock-dusting was done by hand in some working places but this was not done with sufficient frequency and dust was not applied in sufficient quantity to be effective.

According to records of the West Virginia Department of Mines, there were 2.7 pounds of rock dust distributed in this mine last year for each ton of coal produced. This is in excess of the average amount applied throughout the State of West Virginia. A study of the analyses of the dust samples collected during the investigation indicates that, with the exception of the haulage roads, insufficient rock dust has been applied to protect this mine from the propagation of an explosion.

The Bureau of Mines has determined, by experiment and test at its experimental mine, that the dust on ribs, roof, floor, and timbers must contain at least 65 percent incombustible matter to afford protection against the propagation of an explosion; moreover, the incombustible content of the dust should be increased 1 percent for every 0.1 percent of methane present in the air current.

A total of 54 samples of roof, rib, and floor dust were collected in connection with this investigation. The locations at which these samples were collected are shown on the map in appendix "A". The samples were analyzed at the coal laboratory of the Bureau of Mines, Pittsburgh, Pa., and the results of the analyses are shown in table 2.

The amount of rock dust necessary to render the coal dust inert, and incapable of propagating an explosion, depends upon the amount of dust and incombustible matter originally present; the fineness of the dust; the deposition of dust on ribs, roof, floor, timbers, and ledges; the practices likely to produce coal dust; and the amount of dust formed or deposited from day to day.

The results of the analyses of 10 dust samples collected in the "box-heading" entries, inby No. 3 left section, indicate the incombustible content of the rib and roof samples varied from 13.6 to 61.7 percent, with an average of 24.9 percent. Those collected from the floor, at the same locations, indicate the incombustible content to range from 13.1 to 54.0 percent, with an average of 24.2 percent.

Four dust samples were collected in the 3 left section, approximately 600 feet inby the "box heading". The incombustible content of the roof and rib samples taken on the haulage road was 84.5 percent and that of the floor samples was 42.5 percent. Analyses of corresponding samples collected in the air course, parallel to the haulageway, indicate the incombustible content of the rib and roof dust to be 12.4 percent and the floor dust to be 18.2 percent.

Additional dust samples collected in the 3 left section, approximately 1,000 feet inby the "box heading," indicate the haulage-road rib and roof dust contains 13.8 percent incombustible; and the floor dust to contain 14.3 percent incombustible. Roof-and-rib, and floor-dust samples collected approximately 200 feet inby, indicate the incombustible content to be 97.4 percent and 34.4 percent, respectively.

Roof-and-rib, and floor-dust samples collected on the main haulageway, 450 feet inby 1-1/2 right, indicate additional rock-dusting is required, as the incombustible content was but 46.1 percent and 45.5 percent, respectively.

Analyses of 12 dust samples collected in the 2 left area, indicate that at only one location, on the haulage road approximately 100 feet inby 4 left return parallel, was the incombustible content in excess of the recommended 65 percent. At this location, the incombustible content of the rib and roof dust was 68.5 percent and that of the floor dust was 34.0 percent. The incombustible content of the samples of rib and roof dust in the 2 left area ranged from 16.5 to 58.2 percent, with an average of 34.3 percent. The floor-dust samples ranged from 16.1 to 26.7 percent incombustible, with an average of 19.8 percent.

The analyses of roof-and-rib and floor-dust samples, collected on the 1-1/2 right haulage road, approximately 700 feet inby the main haulageway, indicate the incombustible content to be 45.4 and 37.5 percent respectively. Rib-and-roof dust samples, collected in the parallel air course at the same location, ranged from 24.3 percent to 25.5 percent. No floor-dust samples were collected in the parallel air courses, due to accumulations of water on the floor.

Dust samples were collected in the right return air courses, parallel to the main haulage road, at locations near the return airshaft. Analyses of these samples indicate the incombustible content of the rib and roof dust ranges from 13.5 to 22.0 percent, with an average of 19.3 percent. The floor dust ranges from 17.0 to 21.1 percent incombustible, with an average of 19.1 percent.

Analyses of dust samples collected in the right intake air courses parallel to the main haulage road, approximately 600 feet inby the return airshaft, indicate the incombustible content of the rib and roof dust of these entries ranges from 18.8 to 24.3 percent, and the average to be 21.6 percent. The floor-dust samples, at the same locations, range from 15.6 to 24.8 percent incombustible, with an average of 20.2 percent.

Samples of dust collected in the left return air courses parallel to the haulage, approximately 800 feet inby the return air shaft, when analyzed, indicated that the incombustible content of the rib-and-roof dust varies from 20.7 to 25.5 percent, and that of the floor dust to range from 15.5 to 23.0 percent. The average incombustible content was 23.1 and 19.3 percent respectively.

Analyses of dust samples, collected in the intake air courses to the left of the haulage road and at a location approximately 700 feet inby the return airshaft, indicate the incombustible content of the roof-and-rib dust to average 24.9 percent and that of the floor dust to average 23.5 percent. A sample of the rib-and-roof dust collected on the haulage road at this location was found to contain 55.5 percent incombustible and that collected of the floor dust contained 75.7 percent incombustible matter.

Rock-dusting, to be effective, must be done thoroughly and must be well-maintained. All underground openings, of every description, should be thoroughly rock-dusted. Before rock-dusting is done, all combustible matter, such as machine cuttings, and loose coal accumulated along the ribs in working places and spilled along the haulage road, should be loaded out. Preferably, all passageways and openings should be washed down prior to the application of rock dust. Active workings should be rock-dusted first. The rock dust should be applied from the faces outby and the rock-dusting advanced as the faces progress. The surfaces of all crosscuts, entries, pillar workings, and air courses should be kept rock-dusted to within at least 40 feet of the face. Air courses and trackless entries should be rock-dusted by means of tubing extending from a high-pressure, rock-dusting machine to the trackless entries, through doors or "capped" pipes leading through the stoppings. These openings should be kept tightly closed when not in use.

To establish and maintain the required incombustible content of the coal dust, it is necessary to collect samples of the dust at frequent intervals throughout the entire mine. The incombustible content of these samples can be readily determined by means of a volumeter.

Since the explosion, the management has placed an order for a high-pressure rock-dusting machine and two semi-portable rock-dusting machines for use at this mine. One of the semi-portable machines was delivered previous to the completion of the report.

TABLE 2. - Analyses of dust samples collected in No. 3 mine
Christopher Coal Company
Osage, Monongalia County, West Virginia
May 22, 1942.

Can No.	Location in mine	Kind of sample	Percent Combustible, V.M.+F.C.	Percent Incombustible, Moisture + ash	Percent Through 20-mesh	Remarks
M-339	Box heading haulage, 1,200 ft. inby 3 left haulage	Rib & roof	38.3	61.7	73.3	Rock-dusted
L-482	do.	Floor	46.0	54.0	77.3	do.
K-566	Box heading No. 1 ft. aircourse 1,200 ft. inby 3 left haulage	Rib & roof	85.5	14.5	34.5	
K-124	do.	Floor	81.8	18.2	46.8	
K-551	Box heading No. 2 right air course 1,400 ft. inby 3 left haulage	Rib & roof	84.7	15.3	41.9	
K-861	do.	Floor	86.9	13.1	38.4	
B-896	Box heading No. 2 left air course 1,150 ft. in 3 left haulage	Rib & roof	86.4	13.6	70.2	
B-643	do.	Floor	80.7	19.3	59.3	
K-849	Box heading No. 1 left air course 1,150 ft. inby 3 left haulage	Rib & roof	80.4	19.6	72.8	
B-683	do.	Floor	83.6	16.4	58.1	
M-794	3 left - right air course 650 ft. inby box heading	Rib & roof	87.6	12.4	50.7	
M-876	do.	Floor	81.8	18.2	52.6	
L-440	3 left haulage - 5[illegible]0 feet inby box heading	Rib & roof	15.5	84.5	89.6	Rock-dusted
M-725	do.	Floor	57.5	42.5	48.5	Rock-dusted
B-723	1,000 ft. inby box heading	Rib & roof	86.2	13.8	58.7	
M-716	do.	Floor	85.7	14.3	57.9	
M-472	First crosscut between 1 and 2 sections, 3 left, 1,200 ft. inby box heading	Rib & roof	2.6	97.4	98.9	Rock-dusted
M-123	do.	Floor	65.6	34.4	66.5	Rock-dusted
L-19	Diagonal to No. 1 right return Parallel, near return airshaft	Rib & roof	78.0	22.0	72.8	

TABLE 2. - Analyses of dust samples collected in No. 3 mine
Christopher Coal Company
Osage, Monongalia County, West Virginia
May 22, 1942 (Cont'd)

Can No.	Location in mine	Kind of sample	Percent Combustible, V.M.+F.C.	Percent Incombustible, Moisture + ash	Percent Through 20-mesh	Remarks
L-271	Diagonal to No. 1 right return Parallel, near return airshaft	Floor	83.0	17.0	31.9	
J-606	Diagonal to 3 right return Parallel, near return airshaft	Rib & roof	86.5	13.5	65.8	
J-933	do.	Floor	78.9	21.1	38.7	
J-846	No. 2 right parallel intake entry 650 ft. inby return airshaft	Rib & roof	81.2	18.8	34.2	
L-512	do.	Floor	84.4	15.6	45.0	
L-288	No. 1 right parallel intake entry 550 ft. inby return airshaft	Rib & roof	75.7	24.3	39.1	
J-962	do.	Floor	75.2	24.8	25.0	
B-873	No. 3 left parallel intake entry 750 ft. inby return airshaft	Rib & roof	76.0	24.0	65.1	
B-999	do.	Floor	77.4	22.6	54.9	
B-807	1,000 ft. inby return airshaft main haulageway	Rib & roof	44.5	55.5	76.7	Rock-dusted
L-95	do.	Floor	24.3	75.7	69.9	Rock-dusted
J-45	No. 4 left parallel intake entry 700 ft. inby return airshaft	Rib & roof	74.6	25.4	72.5	
B-875	do.	Floor	75.7	24.3	46.5	
M-74	No. 2 left parallel return entry 800 ft. inby return airshaft	Rib & roof	74.5	25.5	76.2	
J-743	do.	Floor	77.0	23.0	50.0	
L-421	No. 3 left parallel return entry 800 ft. inby return airshaft	Rib & roof	79.3	20.7	71.1	
K-829	do.	Floor	84.5	15.5	48.9	
M-193	1-1/2 rt. haulageway 700 ft. inby main haulageway	Floor	62.5	37.5	63.2	Rock-dusted

TABLE 2. - Analyses of dust samples collected in No. 3 mine
Christopher Coal Company
Osage, Monongalia County, West Virginia
May 22, 1942 (Cont'd)

Can No.	Location in mine	Kind of sample	Percent Combustible, V.M.+F.C.	Percent Incombustible, Moisture + ash	Percent Through 20-mesh	Remarks
M-401	1-1/2 rt. haulageway 700 ft. inby main haulageway	Rib & roof	54.6	45.4	85.1	Rock-dusted
M-371	1-1/2 right, No. 1 right air course 700 ft. inby main haulageway	Rib & roof	75.7	24.3	70.7	
M-117	1-1/2 rt, No. 2 right air course 700 feet in main haulageway	Rib & roof	74.5	25.5	82.6	
G-21	Main haulageway, 450 feet inby 1-1/2 right	Rib & roof	53.9	46.1	75.3	Rock-dusted
L-278	do.	Floor	54.5	45.5	89.3	Rock-dusted
B-994	No. 2 left, 3 section, No.2 entry 200 ft. inby 4 left return parallel	Rib & roof	80.3	19.7	73.5	
G-38	do.	Floor	83.0	17.0	43.0	
K-851	No. 2 left, 4 section, No.2 entry 300 ft. inby 4 left return parallel	Rib & roof	83.5	16.5	75.9	
G-923	do.	Floor	83.9	16.1	51.2	
K-850	No. 2 left, 1 section, No. 1 entry 100 feet inby 4 left return parallel	Rib & roof	81.5	18.5	76.2	
K-857	do.	Floor	80.4	19.6	47.5	
J-519	No. 2 left haulageway to 3 section 100 feet inby 4 left return parallel	Rib & roof	31.5	68.5	82.7	Rock-dusted
J-583	do.	Floor	66.0	34.0	58.1	Rock-dusted
L-462	No. 2 left haulageway to 2 section 50 ft. inby 4 left return parallel	Rib & roof	41.8	58.2	77.2	Rock-dusted
L-270	do.	Floor	81.5	18.5	53.2	Rock-dusted
G-78	No. 2 left, 2 section, 1 entry 150 ft. inby 4 left return parallel	Rib & roof	49.3	50.7	84.5	
J-587	do.	Floor	73.3	26.7	46.1	

FIRST AID AND MINE RESCUE

It is reported that about 50 percent of the employees have had first-aid training but no general training or retraining has been done since 1939. Ninety percent of the underground officials were trained in mine rescue in 1940 but have not had any additional training. Twelve men trained in mine rescue are retrained semi-monthly. Two of these men were from the No. 3 mine and were killed in the explosion. The company maintains a mine rescue station equipped with six oxygen breathing apparatus, six All-Service gas masks, oxygen pump, inhalator, and carbon-monoxide detector, which are kept in good condition. This station is located at the Robinson Run mine about 3 miles from No. 3 mine.

The State of West Virginia also maintains a mine rescue station at the Robinson Run mine and a trained team, composed of six men from the Christopher mines. The State also maintains a mine rescue station and team at Maiden mine, four miles from No. 3 mine. Other nearby State-trained teams and mine rescue stations are at Jamison No. 8 mine, Farmington, W. Va., 19 miles from Osage, and at Monongah, W. Va., 24 miles from Osage, W. Va.

All of the above teams aided in the recovery operations in connection with the No. 3 mine explosion.

There is no surface first-aid receiving room at the No. 3 mine. Two first-aid stations are provided underground, one being located in each section. Stretchers, blankets, bandages, splints, and a first-aid kit are kept at each station. In addition, stretchers, blankets, first-aid kits, and supplies are kept on the surface in the lamp house and in the superintendent's office.

SAFETY ORGANIZATION

A safety director is employed to supervise the safety program at this and four other mines of the company. In addition, a safety inspector is employed to devote his full time to the No. 3 mine. These men make mine inspections, air measurements and analysis, and conduct instruction courses in first-aid and mine rescue training.

During the calendar year 1941, the No. 3 mine worked 274 days, employing an average of 427 men, and produced 1,289,698 tons of coal. During this period there were two fatalities and seventy nonfatal accidents. The accident frequency rate was 87.91, as compared to a frequency rate of 83.32 for the company for this period.

A comparison of the tons of coal produced per fatal accident at this mine, in Monongalia County, and the State of West Virginia follows:

	Fatal Accidents	Tons of coal Produced	Tons per Fatality
Christopher No. 3 mine ..	2	1,289,698	644,849
Monongalia County, W. Va.	15	9,731,347	648,756
State of West Virginia	290	140,944,744	486,016

Safety meetings, in which employees and management participate, are not conducted but regular meetings of the foremen and members of the safety department are held at each mine. Bulletin and poster boards are maintained and printed safety rules are conspicuously posted in the lamp house. The officials and men apparently are interested in the promotion of safety and safe working conditions.

SUPERVISION AND DISCIPLINE

The supervisory personnel consists of a superintendent, a mine foreman, two general assistant mine foremen, one on each of the second and third shifts, six assistant mine foremen, and 18 facebosses. The mine foreman and general assistants are in charge of the entire underground personnel on their respective shifts. Each working area, composed of three mechanical sections, is under the direction of an assistant mine foreman on each shift. Each individual section, comprising a complete mechanical unit, is under the direction of a faceboss during each shift.

A faceboss has a crew of 14 men under his direction and the activities of these men are usually confined to four working places. With this organization, each working place should receive at least one visit from the faceboss every hour and at least one visit by the assistant foreman sometime during the shift. The facebosses have no other duties except the direction of the 14-man face crew. All auxiliary men employed in the area are supervised by the assistant mine foreman in charge of the working area of three sections.

It is reported that the intent of this official organization was to secure close face supervision. The management stated that a faceboss should have had sufficient time to visit each working place every 15 minutes during the shift.

The working places in each section are concentrated in a small area and only a few minutes would be required to cover the territory supervised by each faceboss.

It is believed that adequate supervision is provided but there is a probability that periodic checks and observations of the face supervisors were lacking.

Each faceboss, as well as the other supervisors, are equipped with flame safety lamps for gas-detection purposes and are required to record the results of their inspections in a record book kept in the foreman's station on the section.

Fire-bosses are not employed but each assistant foreman is required to examine the sections under his direction sometime near the end of each shift and report his findings to the succeeding foreman.

Eleven of the eighteen facebosses employed did not possess State certificates of qualification. The three facebosses employed in the explosion area on the shift in which the explosion occurred were not certified; however, the assistant foreman possessed a West Virginia foreman's certificate. It was explained by the management that these men were deemed competent and that they were placed on this particular shift because additional visits from other supervisors are more frequent during the day shift.

FIRE FIGHTING

There are no fire-fighting facilities provided underground except that several sacks of rock dust are usually kept in crosscuts where explosives are stored in each section. Fire extinguishers have not been provided for locomotives or other portable electric equipment or at permanent electrical installations underground. The installation of pipelines in face regions for dust-control purposes, now in progress, will greatly increase the fire protection in face regions. It is pointed out, however, that water is not suitable for electrical fires because of its electrical-conductivity characteristics. Carbon-dioxide fire extinguishers are considered to be the most suitable for fighting electrical fires.

PREVIOUS EXPLOSIONS IN THIS OR NEARBY MINES

There is no record of any explosion ever having occurred in this mine and no major disasters have occurred in the immediate vicinity. There have, however, been a number of major mine disasters in the same coal bed in the Fairmont field, in which this mine is located. Following is a list of these disasters:

Date	Mine	Location of mine	No. lives lost
December 6, 1907	Monongah	Monongah, W. Va.	361
October 19, 1916	Jamison No. 7	Barrackville, W.Va.	10
March 17, 1925	Barrackville	Barrackville, W.Va.	33
January 14, 1926	Jamison No. 8	Farmington, W. Va.	19
April 30, 1927	Federal No. 3	Everettville, W. Va.	97
June 20, 1928	National	National, W. Va.	10
March 26, 1930	Yukon	Arnettsville, W. Va.	12
May 11, 1935	Barrackville	Barrackville, W. Va.	6

PROPERTY DAMAGE

The property damage as a result of this explosion was not extensive. With the exception of more or less slight damage to two cable-reel locomotives and several mine cars, the mine equipment was not greatly disturbed.

Damage to the ventilation facilities consisted of the destruction of one overcast, several concrete-block stoppings, four doors, numerous wood-and-canvas stoppings, and a concrete-block regulator.

Most of the crossbar timbers throughout the affected area were blown out by the explosion but the resulting roof falls were not extensive. Trolley wire and feeder lines were torn down in the three affected working sections and along the haulage road in 1-1/2 right entry but the haulage tracks were not disturbed. The explosion resulted in 10 days lost-time in the operation of the mine; consequently the production of about 50,000 tons of coal was lost. More serious than this was the loss of 56 skilled mine workers, whose production is greatly needed in the war effort. The loss of these workers represents an estimated annual loss in production of about 213,000 tons of coal.

MINE CONDITIONS PRIOR TO EXPLOSION

The weather was cloudy on the day of the explosion and there was a heavy rain storm shortly after the explosion. A recording barometer, located on top of the Watson Building in Fairmont, W. Va., about 25 miles away, indicated that there was a gradual drop in atmospheric pressure from 29.25 inches of mercury at noon, Monday, May 11, to 29.05 inches of mercury at noon Tuesday, May 12, 1942. There was a .05-inch drop from noon on May 12 to 2:00 p.m. It is doubtful that this gradual drop of .25 of an inch of mercury pressure, spread over a period of 26 hours, had any appreciable effect on the liberation of explosive gas into the mine workings.

The mine was operating normally on the day of the explosion. The district mine inspector of the West Virginia Department of Mines had inspected the area of the mine in which the explosion occurred on the previous day and on the day of the explosion he inspected the 3 left area. According to the statements of this inspector, no gas was discovered in the mine during this inspection and no abnormal ventilating conditions were observed. This observation was confirmed by company officials who accompanied the State inspector on these inspection trips.

STORY OF THE EXPLOSION AND RECOVERY OPERATIONS

A man-trip, consisting of the afternoon shift of about 107 men, was due to leave the surface at 2:00 p.m. but this trip was delayed about 20 minutes because a car was off the track on an outbound coal-trip. The man-trip could not enter the mine until the coal-trip arrived at the mine portal because of the single-track haulage road. The man-trip entered the mine at about 2:20 p.m and had traveled about 3,000 feet when the explosion occurred. The air was immediately filled with dust and the men on the trip felt the concussion of the blast. Realizing that an explosion had occurred, the men immediately dismounted from the cars and started for the outside.

The mine power failed (because of the explosion) at about 2:25 p.m. The superintendent sent a man to the substation on the surface to investigate the trouble. The man reported back by telephone that the circuit breakers were out and that there was an unusual odor and smoke coming out of the power borehole. The fan, located near the substation, was not running because the driving belts were off the pulleys. The superintendent tried to call the 1-1/2 right section by telephone but was unable to do so. Shortly thereafter, the dispatcher, located on the main heading about 1,000 feet inby from the junction of 1-1/2 right and the main, called the superintendent and told him that an explosion had occurred in 1-1/2 right and that smoke was drifting up the main heading.

The dispatcher ordered the main line motorman and brakeman, who were nearby, to proceed inby to the 3 left foreman's station and wait for him. He also ordered the "flat-road" motorman and brakeman to do likewise. It later developed that these two men disregarded these orders and attempted to make their way toward the outside through the smoke on the main haulage road. These men were killed by afterdamp before they reached the entrance to 1-1/2 right.

The dispatcher traveled through the "45", the first set of entries to the left, and reached the 3 left section, where he was instrumental in gathering the men and sending them to the 3 left foreman's station. The dispatcher then returned to the main entry haulage road and made his way down the main haulage road to the 3 left foreman's station, where he joined the assistant mine foreman of the 3 left section.

The assistant mine foreman and the mechanic of the 3 left section were in the foreman's station, near the mouth of 3 left at the time of the explosion. Upon feeling the concussion of the blast, the assistant foreman walked out on the main haulage road, where the odors from the explosion were noticeable. He then called the mine superintendent, advising him that "something terrible had happened" and not to put the power on or start the fan until he received further advice. The assistant foreman then traveled up the main haulage road toward 1-1/2 right, a distance of about 1,800 feet, where he encountered smoke. Here he met the motorman and brakeman from the main haulage locomotive. These men told him that something had happened in 1-1/2 right and that they had come from the 45 left heading turnout, located about 1,000 feet inby the 1-1/2 right turn-out. Together they proceeded to a 12-inch borehole that had been recently drilled for the purpose of discharging mine water to the surface. This borehole is located along the main haulage road in a crosscut at the bottom of the main entry, a short distance from the assistant foreman's station.

Upon reaching the borehole, these men met 54 other men from the 3 left area who had already started to erect a barricade in the vicinity of the borehole. The assistant foreman then proceeded to the telephone and called the superintendent, advising him that all of the men from his section and the main haulage motorman and brakeman were with him but they could not escape through the main haulage entry because of smoke and fumes. It was agreed that the assistant foreman would lead the men out by way of the main return on the left side of the mine and that the power would not be put on in the mine or the fan would not be started until the men reached the midway sidetrack, outby from 1-1/2 right. It was agreed that the assistant foreman would call the superintendent by telephone when the party reached this point.

The assistant foreman returned to the borehole where the 54 men had started to erect a barricade. The crosscut, where the barricade was being erected, was between two intake entries and the borehole was located in a 16- by 6-foot offset, cut into the right rib of the crosscut. The crosscut was 7 feet high, 14 feet wide, and 70 feet long. It was the intention to barricade this crosscut at both ends. The men had gathered crossbars, cinder blocks, brattice cloth, posts, nails, saws, and hammers, and had placed 11 crossbars across the mouth of the crosscut. They had also placed a row of concrete-cinder blocks in the space between a leg supporting a crossbar timber and the rib. The barricade was partially completed when the men were informed by the assistant foreman that they would attempt to escape by way of the 3 left return. The assistant foreman instructed the men to take nails, brattice cloth, axes, picks, first-aid kit, and saw with them. They traveled up 3 left haulage road to the 45 left haulage road, down the "45" to the overcast on the left side main return. They entered the main return through a trap door in the overcast. After proceeding some distance it was noticed that the air had started to circulate and the men were overtaken by smoke and fumes.

The men reached the main haulage road and intake air outby the midway sidetrack near the upcast shaft without anyone having been overcome. The assistant foreman directed the men to proceed to the surface through the main haulage entry. He then went to the telephone at the midway sidetrack and called the outside, reporting to Mr. Frank Christopher, President of the company, that he and 56 men had arrived safely.

Orders were issued to start the fan after it was thought that sufficient time had elapsed for the men to reach fresh air. It was imperative that the fan be started as soon as possible in order to get air into 1-1/2 right in the hope that some of the workmen in this section might still be alive.

State Mine Inspector Alex Bryce, Company Safety Director C. P. Pride, Superintendent E. H. O'Neil, and Mine Foreman Howard Feathers, entered the mine and met the men from the man-trip on their way out. They directed them to continue to the outside and then proceeded to the midway sidetrack, where they met the men who had escaped from the 3 left section on their way out. The party then proceeded to the junction of 1-1/2 right, where they cut the power lines so that transportation could be established. Here the party met the dispatcher who had helped gather the men in the 3 left section after the explosion, and after traveling part way out with them had made his way to the intake entries outby from 1-1/2 right by breaking a hole in a concrete-block stopping.

State mine inspectors P. J. McGraw and M. G. Dobbie, in company with James Crockett, an inspector for the Cochran Coal Company, and A. K. Bloom, Federal coal mine inspector, arrived at the 1-1/2 right junction about 6:20 p.m.

Three oxygen-breathing apparatus crews followed this group into the mine. Upon arriving at the 1-1/2 right junction, Mr. McGraw and Mr. Bloom conferred with Mr. Feathers, mine foreman, concerning the damage to the stoppings and the probable course of the air currents in 1-1/2 right. It was then decided to explore the 1-1/2 right entry as far as possible, and this was done by State Mine Inspectors McGraw and Dobbie, Mr. Crocket, and Federal Inspector Bloom. This exploration revealed that the overcast across 1-1/2 right had been demolished and that the air current was short-circuiting at this point. Canvas stoppings were then erected on both sides of 1-1/2 right entry from the intersection to the overcast. While these stoppings were being constructed, the exploration party proceeded inby on the main entry to de-
termine the extent of damage to the stoppings in this area and at the same time
directed the removal to the surface of the three bodies previously located on the main entry. These were the bodies of a pumper and a haulage crew.

When the temporary stoppings had been erected to the overcast, the exploration party traveled to the entrance to No. 1 section and, when no fires were found, directed that temporary stoppings be erected to the entrance to No. 1 section.

An apparatus crew was sent into the No. 1 section to look for bodies and for fire. This crew returned about 8:45 p.m. and reported that no fires were observed and that the atmosphere would sustain the flame of a flame safety lamp.

The exploration party then proceeded to examine the No. 1 section. During this examination the exploration party was joined by J. W. Pero and R. W. Stahl, of the Bureau of Mines. A search of the No. 1 section revealed the presence of 11 bodies. By this time, canvas stoppings had been erected to the No. 1 section. Mr. McGraw, Mr. J. W. Pero, and Mr. James Crockett then explored the 1-1/2 right haulage road to the entrance to No. 2 section. When no fire was discovered and only small concentrations of carbon monoxide were found to be present, they proceeded to explore the No. 2 section. This examination revealed the absence of fire but carbon monoxide was present in dangerous quantities near the face of the No. 2 section. When the party returned to the No. 1 section, they reported finding 15 bodies in No. 2 section, 2 bodies in the wireman's station near No. 2 section, and one body near the entrance to the No. 2 section.

The fresh air base was moved inby No. 1 section and an apparatus crew was sent to explore the main haulage road as far as No. 3 section.

Following this exploration, another apparatus crew was sent to explore 1-1/2 right to a point inby the No. 4 section. They reported extremely bad air, no fires, and no bodies. Mr. McGraw and Mr. Pero then made a short trip into No. 3 section and, when they encountered carbon monoxide, decided to send an apparatus crew to the face of No. 3 section. About this time the recovery party was joined by Messrs. H. H. Kazee and J. R. Dukes of the Bureau of Mines. The apparatus crew explored the No. 3 haulage road to the face and returned. They reported the discovery of seven bodies just inby the left parallel of 1-1/2 right in a crosscut off No. 3 section haulage road.

In the meantime, temporary stoppings had been erected to the entrance to No. 3 section. It was decided to explore the face area of the No. 3 section. Messrs. McGraw and Pero proceeded short distances and made tests for carbon monoxide and methane; the brattice crew followed closely and erected canvas stoppings. The party had proceeded only a short distance when they were joined by Mr. N. P. Rhinehart, Chief of the West Virginia Department of Mines, and State Inspectors at Large, P. F. McLinden, L. S. McGee and Inspector Alex Bryce. The party proceeded slowly, advancing the canvas stoppings continuously, until the loading machine was reached. Three bodies were found near the loading machine and one underneath a cable-reel locomotive just outby the loading machine.

Further observation revealed large concentrations of carbon monoxide and the party suspended operations until better ventilation could be established. By this time it was believed that all men in the section were dead and rapid exploration was not necessary.

About 1 hour previous to this, a crew started sending bodies to the surface. When an hour's wait indicated that sufficient air for recovery was not possible with the temporary stoppings, the party retired to the No. 1 section. It was then decided to reinforce all stoppings with wood and ventilate the No. 3 section. About 7:00 a.m., May 13, the party was joined by Messrs. Joseph Bierer and Robert McIntyre, of the State department of mines, and Messrs. William Stinnette and A. J. Barry of the Bureau of Mines.

During the succeeding days, bodies were removed and normal ventilation established as rapidly as possible. Numerous roof falls, at intersections of working places and at faces of pillar workings, hampered speedy recovery of bodies. By Thursday morning, 45 bodies had been recovered and had been sent to the surface. From this point on, slate and roof falls had to be loaded out to find the remaining bodies. The last, and 56th, body was recovered and sent to the surface at 11:45 a.m., Saturday, May 23, 1942.

An investigation of the explosion was conducted after ventilation was restored to the affected area. The investigating party consisted of N. P. Rhinehart, Chief of the West Virginia Department of Mines; P. F. McLinden, P. J. McGraw, L. S. McGee, Alex Bryce, Joseph Bierer, State Mine Inspectors; E. H. O'Neil, S. P. Pride, Howard Feathers, Christopher Coal Company representatives; and M. J. Ankeny, J. W. Pero, A. K. Bloom, and R. W. Stahl of the Bureau of Mines. A preliminary investigation of the entire area was made by this party on May 14, 15, 16, 18, 19, and 20, 1942. The party was joined by the Honorable M. M. Neeley, Governor of the State of West Virginia, who spent a few hours underground on Wednesday, May 20.

A more detailed investigation of the area was conducted by State Inspectors P. J. McGraw and Alex Bryce, of the West Virginia Department of Mines, and M. J. Ankeny, J. W. Pero, A. K. Bloom, and R. W. Stahl, of the Bureau of Mines, on May 21, 22, and 23, 1942.

DETAIL OF EVIDENCE

The explosion originated in the workings off 1-1/2 right. Since every man who was in the section at the time of the explosion was killed, the cause and probable contributing causes had to be determined by careful observation and study of conditions as they existed after the explosion and by the questioning of foremen and workmen who worked in the area during the preceeding shifts.

The map of the mine, appendix "A," shows the position of the affected area with respect to the other workings and excavations of the mine. This map also shows the coursing of the air, the location where air and dust samples were collected, the probable point of origin, the extent of flame, and the extent of violence.

The map of the explosion area, appendix "B," shows the location of locomotives, cars, cutting and loading equipment, and bodies of workmen, as found after the explosion. The map also shows the location of ventilating doors, stoppings, and overcasts, as nearly correct as could be determined. The direction of the flow of air previous to the explosion and the direction of major forces are indicated by arrows.

Each set of four entries, turned off to the left from 1-1/2 right, comprises a complete working section and the cycle of operations of each mechanical unit is confined to the four entries of a section, the crosscuts therefrom, and the pillar splits. For convenience, the first set of four entries is called the No. 1 section; the second set, the No. 2 section; and the third, the No. 3 section. It will be observed from the map that Nos. 1 and 2 sections are on the retreat and No. 3 section is on the advance but will soon penetrate a caved, mined-out area before starting on the retreat.

Forces

The forces of the explosion traversed the entire area of the workings of 1-1/2 right and extended out into the main entries, where an overcast and several stoppings between the intake and the return both inby and outby 1-1/2 right were blown out.

The lines of force, as indicated by the direction in which stoppings were blown out, the direction in which timbers and other heavy objects, such as cover plates of locomotives, steel explosives-storage boxes, and a locomotive cable-reel were carried, and the deposition of coke on timbers, indicate that the explosion originated at the intersection of the 10th crosscut off No. 3 heading, No. 3 section, 1-1/2 right, and the No. 3 heading. The forces traveled strongly outby on this heading and its parallel entries Nos. 1, 2, and 4. When the forces reached the 1-1/2 right entries they spread in both directions, inby toward the faces of 1-1/2 right and outby toward the entrance of 1-1/2 right. The explosion traveled from the No. 3 section to the No. 2 section through the No. 1 and No. 2 cross-cuts in the barrier pillar between these two sections, as indicated by strong forces through these openings. The velocity through these openings was so great that the floor in places was swept clean and a steel explosives-storage box, located in the No. 1 crosscut, was carried through the crosscut to the No. 1 heading of No. 2 section, where it struck a corner of a coal pillar and ricocheted up this entry a distance of approximately 40 feet. A man, who had evidently been in this crosscut at the time of the explosion, was also projected against the corner of the coal pillar and broken into small fragments. Explosives were spilled from the box and scattered widely throughout this vicinity but there was no evidence of any of the explosives having been detonated. The wooden detonator box was shattered and electric detonators were also scattered over a wide area. There was no indication of explosives having been ignited by the explosion anywhere in the explosion area.

The forces in the No. 2 section were across the pillar line toward No. 1 section and outby toward 1-1/2 right entries. The explosion traveled from the No. 2 section to the No. 1 section through crosscuts in the barrier pillar, indicated by the effect of strong forces on timbers in these crosscuts.

The forces in the No. 1 section were outby on No. 1, 2, 3, and 4 headings. The most positive evidence of this was a cover plate of the locomotive, being used to shift cars at the mouth of No. 1 heading, having been blown outby for a distance of about 50 feet and the body of the motorman blown outby. When the explosion reached the entrance to 1-1/2 right section, the forces spread in two directions, inby and outby on the mains, destroying an overcast, a regulator, and several concrete block stoppings.

The Point of Origin

All available evidence indicates that the explosion originated at the intersection of the 10th crosscut off No. 3 heading, No. 3 section, and the No. 3 heading.

A sketch of the details of the No. 3 section, 1-1/2 right, is shown in appendix "C." It will be observed that the crosscut in which the explosion is believed to have originated was being driven toward the No. 4 heading and the fourth cut had just been completed. The cutting machine had been pulled back from the cut so that the cutter head was about 16 feet from the face. The cutter bar was resting on the floor. Three holes had been drilled across the face near the roof and the fourth and last hole had been completed when the explosion occurred. The augar was found still in the hole, with the hand-held Jeffrey drill attached.

The body of the driller was found about 20 feet from the face on the left side of the place, lying face up with his head pointed outby. The body of the cutting-machine operator was found about 25 feet outby from the controls of the cutting machine on the left side of the place, face down, headed outby. The body of the cutting-machine helper was found about 60 feet outby from the cutting machine and about 25 feet inby from where the cutting machine power nip was attached to the trolley wire.

The drill was of the permissible type but the approval plate was missing and there was a small hole through the screw cover plate of the switch-control housing. Apparently this hole had been burned through the housing, at some time previous to the explosion, by the drill developing an internal short circuit and coming in contact with a ground return. The drill was sent to the electrical testing laboratory of the Bureau of Mines, at Pittsburgh, Pa., for inspection and test. The results of repeated tests, in which the drill was operated in explosive gas, were that the drill failed to ignite gas. It was discovered, however, that the switch in the drill was shunted out so that the mechanical switch-control mechanism had no effect in starting or stopping the drill. It was concluded, therefore, that whenever power was impressed on the drill cable, the drill would run regardless of the position of the controller.

The drill cable was connected to the power source in the control box in the cutting machine so that power would be impressed on the drill whenever the cutting machine nips were attached to the rail and trolley wire; consequently the starting and stopping of the drill could be controlled only by attaching and detaching the nip of the cutting machine.

At some time previous to the explosion, alterations had been made to the control panel of the cutting machine, located inside an explosion-proof housing. These alterations were of such a nature as to render the machine nonpermissible; moreover, the control panel and explosion-proof enclosure were left in such condition that explosive gas could easily get into the enclosure and ignite from the operation of the contactors. Such an explosion occurring within the box could be easily transmitted to the outside.

The alterations referred to consisted of the removal of the main circuit breaker from the control box, together with its reset shaft. This left the machine totally unprotected from overload; moreover, the hole through which the reset shaft previously entered the box provided an opening through which an explosion, originating within the box, could be transmitted to the outside. The normal control circuit of the machine had also been altered. The original control line, leading from the cutter-chain-motor push-button control to the contactor, had been burned off or disconnected and a small two-conductor cable, leading from the push-button control across the top of the machine, under the cover plates and into the hole in the control box to the contactor relay that operates the cutter-chain motor, was substituted. There was no packing gland provided where this cable entered the control box and there was ample space in the opening around the cable for the transmission of flame.

The interior of the box showed indications of previous trouble. There was evidence that rock dust had been used to put out a fire in the control box at some previous time. The contactors were covered with a thin layer of rock dust and there was a considerable accumulation of rock dust on the floor of the box. There was also evidence that the two conductors of the main power circuit, at some time previous, had burned off. These conductors had been spliced by twisting the ends together and were insulated with friction tape. An examination of these connections revealed that there had been recent heating and the insulation at the joints had burned off. These conductors coming in contact with each other would have caused a direct short circuit of the main power circuit and would have undoubtedly burned off or at least shown the effect of beading. There was some slight beading indicated but it is believed that this was caused when the cable originally burned off, before it was repaired.

In addition to the hole in the top of the control box, there were three bolts missing from the bottom of the cover plate and the clearance between the cover plate and the box was in excess of .008 of an inch. The machine had recently been in operation and was naturally warm. The faulty connections in the box were probably hot. These conditions would promote rapid transpiration of air between the inside and the outside of the box. If there was an explosive mixture of methane and air on the outside of the box, it would be drawn rapidly into the box. The normal operation of the electrical contactors within the box would ignite such a mixture and the resulting explosion could easily be transmitted to the outside.

A careful study of the location and position of the bodies of the three men working in the No. 10 crosscut and of the location and condition of the equipment, enabled the investigators to determine, with a fair degree of certainty, what these men were doing at the instant the explosion occurred. The driller and the cutting-machine helper had finished drilling the last hole at the face. The driller probably remained at the face to hold the drill while the helper started back to remove the machine nips from the trolley wire. Meanwhile, the cutting-machine operator was apparently preparing to tram the cutting machine back from the face, preparatory to blasting. This would logically have been done before the helper removed the nip from the trolley wire. With the driller holding the drill at the face, and the helper on his way back to remove the nip, the cutter probably operated the control button to start the tramming motor. It is believed that the resulting spark, or arc at the contactor within the control box ignited gas and the explosion was transmitted to the surrounding atmosphere through the hole in the top of the box and the excessive clearance at the lower edge of the cover plate.

The most positive evidence that the explosion originated at the control box of the cutting machine was the position of the sheet-metal rope and sheave guards, or shields, located immediately above the control box and the position of the center cover plate. These sheet-metal guards were blown outward and bent into such position as to indicate that the explosion came from within the frame of the machine. The cover plate was up-ended and apparently slid down on the opposite side of the machine, further indicating that the original burst of the explosion came from within the framework of the machine. A sketch showing the actual displacement of the top cover plate and side shields of the cutting machine located in No. 3 section is contained in appendix "D". This evidence leads the investigators to believe that the explosion originated in the control box of the Sullivan 7 A. U., cutting machine at No. 10 crosscut, No. 3 heading, 3 left.

This cutting machine was of a permissible type, bearing an approval plate of the Federal Bureau of Mines. A facsimile of the approval plate issued for the Sullivan 7 A.U. machine is shown in appendix "F" of this report. The caution statement on this approval plate contains, in part, the following warning:

Caution

This equipment is not permissible except when used under the following conditions:

1. General safety: Frequent inspections must be made. All electrical parts, including the trailing cable and the wiring, must be kept in a safe condition. There must be no openings into the casings of the electrical parts. A permissible junction box must be used in connecting to power circuit unless connection is made in pure intake air.

2. Fastenings: All bolts, nuts, screws, and other means of fastening must be in place, properly tightened and secured. All screw covers must be kept locked or sealed. Only one key or sealing tool shall be available and it shall be in the care of an authorized person.

Permissible equipment is intended to eliminate, from the face regions and return air currents, open arcs and sparks which constitute the most prolific source of gas ignition in coal mines. It is not intended that this equipment be operated in the presence of explosive gas but it is so designed that should explosive gas suddenly appear no ignition will occur, provided the equipment is maintained in a permissible condition. The effectiveness of permissible equipment in preventing ignitions depends entirely upon how closely the warnings on the caution statement are followed. It is believed that if all of the equipment used in the face regions of this mine, including the gathering locomotives, were of the permissible type and this equipment had been maintained in a permissible condition and operated in a permissible manner, the disaster would not have occurred. It is probable that the gas would have been swept away by the ventilating current or would have been discovered before an ignition took place.

Source of the Gas

There are at least two possible sources of explosive gas indicated by the evidence.

It is possible that the cutting machine, which had finished cutting the face of the No. 10 crosscut a few minutes before the explosion, or the drill may have cut into a small gas feeder, resulting in the liberation of gas into the working place.

Tests were made at the face of this place on May 14, 1942 with a W-8 methane detector, previous to the complete restoration of ventilation, and 0.5 percent methane was found near the roof. On the following day, after ventilation had been restored, the place contained 0.15 percent methane near the roof and more than 5.0 percent in the boreholes. Officials of the company report that accumulations of gas have not been encountered in solid work.

Another possible source of the gas is from the pillared area adjacent to the solid place in which the cutting machine had finished cutting.

Officials of the company assert that explosive gas has not been detected on the pillar falls along the pillar line of No. 1 and No. 2 sections since the pillaring operation was started in these sections. The official State report book was kept in the assistant foreman's station on 1-1/2 right near the entrance to No. 3 section. This book could not be located following the explosion and duplicate records of official examinations of working places were not maintained on the surface. The management informed the investigators that explosive gas was encountered along the pillar lines of No. 2 right. This section, of which No. 1-1/2 right pillar line is a continuation, has been worked out and abandoned.

There is no doubt that the gob areas of the No. 2 right section and the caved areas back of the pillar line of No. 1-1/2 right contained large bodies of explosive gas, as proved by the fact that the workings of Nos. 1, 2, and 3 sections of 1-1/2 right were filled with explosive gas following the recovery operations, before the ventilation was restored to normal, and explosive gas was detected in a working place near the return end of the pillar line on May 15, 1942, 3 days after the explosion, when the ventilation was restored to almost normal condition. There is no place that this gas could have come from except the caved areas back of the pillar line.

The working place, No. 9 crosscut off No. 3 heading, which is adjacent to the working place in which the explosion originated, cut through into this worked-out and caved area at about 11:10 a.m. on the day of the explosion. This was about 3 hours and 15 minutes before the explosion occurred. By questioning the assistant mine foreman and section foreman of the preceding shift, the investigators were able to determine the location of the cutting and loading machines at the beginning of the shift on which the explosion occurred and the number of cuts taken out from the time the shift started until the explosion occurred. Knowing the location of the machines and the condition of the working places at the time of the explosion, a timetable was worked out that would indicate, with a fair degree of accuracy, the time each cut was made during the shift. The results of this study are shown in a diagram contained in appendix "E" of this report. The following conclusions were reached as a result of this investigation:

1. Thirteen cuts were made during the shift.
2. The machine cut through into the caved area at about 11:10 a.m., or 3 hours and 15 minutes before the explosion took place.
3. The machine made two additional cuts in the place after it had cut through into the caved area.
4. The machine had made one cut in the place in which the explosion originated, earlier in the day, and had completed the second cut in this place when the explosion occurred.
5. The machine was probably in such condition that it would have ignited gas at any of the times it was in the place that was cut through to the caved area, if gas had been present.
6. An unusual chain of circumstances was necessary to permit gas to issue from the cut-through into the gob and find its way into the adjoining working place where the cutting machine was located at the time of the explosion.

7. An interruption of the ventilation would relieve the pressure on the gobs and allow gas to flow from the opening and flood the working places.

8. The movement of the large 10-ton cars outby from the loading machine that was in the place at the time, would produce a suction effect and greatly accelerate the release of gas from the gobs.

9. The movement of the cars inby toward the loading machine would swirl the gas, accelerate its mixture with air and force the mixture into openings leading to adjacent working places.

The map of the explosion area, appendix "B," shows the ventilation and the location of locomotives, cars, and other equipment at the time of the explosion. The service locomotive in No. 1 left was in the act of shifting cars. From the conditions observed in this section, it is apparent that the locomotive crew had left an empty car under the boom of the loading machine, as is sometimes the practice, so that the machine could load the car while the locomotive went out onto 1-1/2 right heading for more empty cars. Returning with three empty cars, the locomotive pushed the cars up to the loading machine, coupled onto the loaded car, pulled the loaded car and the three empty cars out on the straight heading, and was in the act of pushing the trip into the loaded car chute when the explosion occurred. The next move of the locomotive crew would have been to uncouple the load, pull out on the straight heading, and push the trip of three empty cars up to the loading machine ready to start to load. The operation described in the foregoing procedure would have required the passage of the locomotive through the door on No. 1 left three times within the space of about 10 minutes. The indications are that the door was open at the time of the explosion. The door was torn off its hinges and deposited a short distance outby its original position but was not broken. The door frame was blown out. One of the cover plates of the locomotive was blown outby from the original location of the door. The inby edge of the door was coated with a deposit of coke. While there is ample evidence that this door was standing open at the instant of the explosion, it is not known whether the door was opened momentarily or whether it was left latched open for a period of 10 minutes. The latter could easily have been the case.

The effect of the open door at No. 1 left would be to short-circuit the air from the No. 2 and No. 3 sections. This would relieve the air pressure on the pillar falls and allow the gas to issue from the opening cut through into the gob, if gas were present.

In considering the circumstances that caused the gas to flow out of the caved areas, the investigators acknowledge that the gas may have been forced out of the gobs into the working places by a heavy fall back in the caved areas but there is no way to determine whether or not this may have occurred. The matter is mentioned here to indicate that it is the opinion of the investigators that this explosion could have occurred without the air having been short-circuited.

EXTENT TO WHICH COAL DUST ENTERED INTO THE EXPLOSION

The 1-1/2 right area, in which the explosion occurred, was dry and dusty and there were large accumulations of coal dust on roadways, the floors of trackless entries, and other openings. Water was not used to allay the dust at working faces and rock dust was used sparsely in active workings. Widespread coke deposits on timbers, equipment, and on the roof in many places throughout the explosion area, indicate that coal dust was extensively involved in this explosion.

It is conceivable that had adequate safeguards been provided against the coal-dust explosion hazard by the use of water in face regions and the application of rock dust in sufficient quantities, many, or at least some, of the men who were killed would have escaped.

STATE INSPECTORS' CONCLUSIONS

There has been no official statement made by the West Virginia Department of Mines as to the cause of this explosion up to the date of the completion of this report. The representatives of the State who investigated this explosion concurred unofficially with the Federal investigators as to the origin and cause at the completion of the investigation.

CORONER'S VERDICT

The Monongalia County coroner's inquest into the cause of death of the victims of the explosion has not been held. It is understood that the coroner's inquest will be held soon after the West Virginia Department of Mines has completed its report.

SUMMARY OF EVIDENCE

1. Evidence indicates that the forces radiated from the No. 10 crosscut, No. 3 heading, 3 left. The forces were strongly outby on this heading and its parallels.
2. The control box on the cutting machine in the No. 10 crosscut was in such condition that it could easily ignite gas.
3. A reconstruction of the probable movement of the men in No. 10 crosscut indicates that a contactor within the control box was being operated at the time of the ignition.
4. The condition in which the cutting machine was found indicates that a burst of pressure came from within the frame of the machine in the vicinity of the control box, bending the side shields outward and lifting the center cover plate off the top of the machine.
5. The machine cut through into an abandoned, caved, pillared area in the adjacent working place about 3 hours and 15 minutes before the explosion occurred.

6. The working places in the 3 left section were filled with explosive gas on the day after the explosion occurred.

7. The pillar line of the caved pillared area, that was cut into by the machine, was liberating methane at the rate of 46,656 cubic feet per 24 hours after the ventilation had been restored to normal but before the mine had resumed operation.

8. The door at the entrance to 1 left, upon which the 3 left section depended for ventilation, was apparently open at the time of the explosion.

9. A gathering locomotive and cars were shuttling back and forth in the No. 9 crosscut, recently cut through into the gob, immediately prior to and at the time of the explosion. This would aid in the liberation of gas from the cut-through and would have the effect of mixing the gas with air and forcing it through the openings into adjacent working places.

10. Widespread deposits of coke, in large quantities, indicate that coal dust contributed greatly to the extent and violence of the explosion.

11. There was no evidence that any shots were being fired anywhere in the explosion area at the time of the explosion.

12. While all of the permissible electrical equipment in the explosion area was found to be in a nonpermissible condition, no evidence was found in the vicinity of any of this equipment, with the exception of the cutting machine in No. 3 section, that would indicate that it may have initiated the explosion.

PROBABLE CAUSE OF THE EXPLOSION

It is the opinion of the Bureau of Mines investigators that the explosion originated at the intersection of No. 10 crosscut, off No. 3 heading, 3rd left; and the No. 3 heading, 3rd left, by the ignition of explosive gas and was propagated throughout the affected area by gas and coal dust; that the gas came from a feeder or pocket in the face of the crosscut in which the explosion originated or from an adjacent working place that was cut through into a caved area on the shift on which the explosion occurred; and that the gas was ignited by an arc or spark from a contactor in the control box of a permissible-type cutting machine that had been rendered nonpermissible and capable of igniting gas by a faulty repair job.

LESSONS TO BE LEARNED FROM THE CONDITIONS AS THEY RELATE TO THIS EXPLOSION

There are eight outstanding lessons to be learned from this explosion:

1. Sudden and unusual liberations of explosive gas can occur in any coal mine; therefore, all coal mines should be so developed and operated that if and when such liberations of gas do occur, no ignition sources will be present.

2. The use of permissible-type mining equipment does not afford protection against the ignition of gas unless such equipment is maintained and operated in a permissible manner in accordance with the caution statements on the permissible labels.

3. Failure to provide effective bleeder systems permits the accumulation of explosive gas in worked-out caved areas. Such accumulations may be liberated into working places by derangement of the ventilation or may be forced out into live workings by extensive falls of rock.

4. Coal-mine ventilating systems must be so designed that interruptions of the ventilating current, with consequent relief of pressure on caved areas, cannot occur. To place reliance for continuous ventilation on a single mine door equipped with a latch, or on a single source of power for the fan, involves too great a risk.

5. Propagation of explosions by coal dust cannot be prevented unless all openings are adequately rock-dusted close to the working faces and the face regions are kept wet. The rock-dusting of haulage entries only, affords practically no protection against the propagation of a coal-dust explosion throughout the mine.

6. Electrical equipment, whether permissible or not, must not be taken into any place if there is gas present in sufficient quantities to be detected with a flame safety lamp. This explosion emphasizes the necessity for closer inspection of working places for gas by competent supervisors before electrical equipment is taken to the working faces. Special vigilance must be maintained when places are cut through to gobs or other worked-out, abandoned areas.

7. The difficulty of locating and identifying bodies following the explosion makes clear the necessity for a positive check-in-and-out system, with a requirement that all employees carry a positive means of identification on their person at all times while underground.

8. The explosion could have been prevented without wide departure from present mining methods, conditions, and practices, particularly with reference to the maintenance and use of permissible electrical equipment, proper ventilation, and adequate inspections.

RECOMMENDATIONS

The following recommendations are made in the belief that their adoption will materially lessen the chances of an explosion occurring in this mine in the future.

Ventilation and Gas

1. The ventilation system of the mine should be redesigned so that each mechanical section or unit will be ventilated with a separate split of pure intake air.

2. Splitting of the air should be accomplished by means of overcasts, substantially constructed of incombustible material.

3. Doors should not be used to control the ventilation except where absolutely necessary.

4. Where it is necessary to use doors to control the ventilation, they should be erected in pairs to form an air lock between them so that when one door is open the other, having the same effect on the ventilating current, can remain closed.

5. Doors should not be provided with latches or other devices to hold them open.

6. Provision should be made in the ventilating system for effective bleeder openings into worked-out caved areas, so that these areas will be kept as free as possible from accumulations of explosive gas and a positive pressure will be maintained continuously along the pillar lines.

7. Stoppings on producing entries should be tightly constructed of incombustible material.

8. The ventilating current should be checked close to the pillar lines so that no less than 6,000 cubic feet of air per minute can be measured in the last open crosscut of each heading.

9. A qualified foreman, certified by the West Virginia Department of Mines, should be placed in charge of each mechanical section or unit.

10. The section foreman should be required to examine each working place for explosive gas immediately before any electrical equipment is taken beyond the last open crosscut in such working place. No electrical equipment should be kept in any working place more than 15 minutes unless a reexamination of the place is made by the section foreman.

11. All working places and all places adjacent to working places, including openings leading to caved areas, should be examined for gas by a certified mine official not more than 3 hours before any shift enters the mine.

12. The section foreman, or other certified official authorized to examine working places, should be required to enter a report in the State record book of all dangers found. If the record book is kept underground the official should be required to enter a duplicate report in a duplicate record book on the surface at the end of his shift.

13. When explosive gas is found in any working place or places in a mechanical section, the section should be "dangered off" and the power cut off from the section. Power should not be restored to the section until after the gas has been removed.

14. Two independent sources of power, immediately applicable, should be provided at the mine fan.

15. The fan should be provided with a device that will give visual and audible warning to the fan attendant, or other responsible person, when the fan is not operating normally.

16. An automatic relay device should be provided that will cut the power off from the mine in the event the fan fails to operate normally.

17. The pressure-relief door on the fan should be made operative by the substitution of fastenings made of easily ruptured metal, instead of steel bolts.

Electricity

1. Trolley wires and bare feeder wires should not be installed in the mine in other than pure intake air, "pure intake air" being defined as (a) air which has not passed through or by any inactive workings and (b) air which has not passed through or by any inactive workings, unless these are sealed

effectively, and (c) air which is free from poisonous gas and by analysis contains not less than 20 percent oxygen (dry basis) and not over 0.05 percent inflammable gas; nor should they be installed past open rooms or crosscuts, whether working or abandoned, or in entries or other workings which act as returns for open active or inactive workings.

2. All electrical equipment used at or near the face of the workings, such as mining machines, loading machines, drills, and pumps, should be of the permissible type and this equipment should be maintained in a permissible condition. Such equipment should be operated and maintained in accordance with the instructions contained in the caution statements of the approval plates.

3. All electrical equipment used in face regions should obtain power through fused nips located in pure intake air or through permissible junction boxes in other than pure intake air.

4. Gathering and haulage locomotives, when operated in other than pure intake air, should be of a permissible type.

5. If the use of cable-reel locomotives for gathering purposes is continued, the motors, controllers, resistance units, and all other electric parts should be enclosed in flameproof housings and two-conductor cables should be used to supply power to the locomotives.

6. When trailing cables fail or become damaged, they should be replaced by standby cables and the defective cable should be taken to the repair shop to be repaired. Only vulcanized splices should be used.

7. Where track is used for the return circuit of any electrical equipment, including gathering locomotives, both rails should be well bonded at every joint and they should be cross-bonded at least every 200 feet.

8. All permissible electrical equipment should be inspected daily by a competent person who should be required to make a written report on the condition of such equipment. It should be the duty of the person making the inspections to see that (a) such equipment is maintained in a permissible condition, and (b) that it is not used in a nonpermissible manner.

9. All major repairs to electrical equipment and all repairs that involve the opening of explosionproof enclosures should be made in the machine shop.

Dust

1. Provision should be made to apply water on the cutter bars of all mining machines, or to spray the dust as it emerges from the kerf, and the coal cuttings should be kept wet as the cutting is being done.

2. All working places should be thoroughly wetted with water in the face regions before and after blasting.

3. Water should be applied to the coal as it is being loaded by the loading machines.

4. The tops of loaded cars should be thoroughly wetted in the working places to avoid the distribution of coal dust along haulage roads.

5. The coal face and the working place 40 feet therefrom should be kept free of coal dust by the use of water.

6. Haulage entries and working places should be kept cleaned up and free from spilled coal and coal dust.

7. Rock dust should be applied to every mine surface, on haulage entries, return airways, crosscuts, and pillar workings, to within 40 feet of the working faces.

8. The rock dust should be applied to the roof, ribs, floors, timbers, and other mine surfaces in such quantities that the incombustible content of the dust will not be less than 65 percent. If gas is present in the air current, 1 percent of additional rock dust should be applied for each 1/10 percent of gas.

9. Dust samples should be collected at frequent intervals, at representative points in the mine, to maintain a check on the condition of the dust as to explosibility. Redusting should be done before the incombustible content falls below the limit stated in the preceding recommendation.

10. Return airways, trackless entries, and other openings that have not previously been cleaned, should be cleaned of fine coal dust before rock dust is applied.

11. Provision should be made in stoppings between intake and return airways to convey rock dust into the trackless entries by means of the hose of a high-pressure rock-dusting machine or other adequate method. Air-tight trap doors or capped pipes in the stoppings are suggested if a high-pressure rock-dusting machine is used.

Explosives and Blasting

1. All shots should be charged, stemmed, and fired by competent shot-firers who have been trained in the proper use of explosives and who are familiar with the use of the flame safety lamp in testing for gas.

2. In the absence of a State system of certification for shot-firers, the company should establish some system of qualifying men for this position.

3. No borehole should be charged or fired in any working place if gas is present in sufficient quantity to be detected with a flame safety lamp.

4. Each borehole should be charged and fired before a subsequent hole is charged.

5. Explosives should not be taken to the face of any working place while electrical equipment is in the place.

6. Explosives-storage boxes should be kept locked. Keys to these boxes should be carried by authorized persons only.

General

1. A record should be kept in a safe and quickly accessible place on the surface, which will show the time when each person goes into and comes out of the mine; and which will also show, insofar as practicable, where he may be found while in the mine.

2. Each underground employee should be required to carry on his person, at all times while underground, a brass check or other means of identification.

3. Carbon-dioxide fire extinguishers should be installed on all locomotives, cutting machines, loading machines, and at all underground pumps.

4. A supply of rock dust for fire-fighting purposes should be kept on both sides of all mine doors and at all foremen's stations underground.

5. A definite mining plan for development work and pillar extraction should be adopted and followed so that a continuous fracture line may be maintained throughout each working area.

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